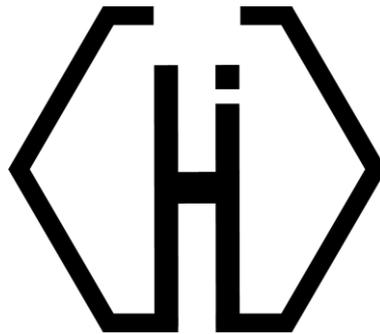




Developed to meet the high demands of the  
European Automotive Industry.

- ⚙️ **Scalable & Flexible** – Adapts from small projects to enterprise systems
- 🔗 **Open Architecture** – Extensible, customizable and future-proof
- 🔗 **Seamless Integration** – Works standalone, in larger systems or collaboratively in swarms
- 💰 **Cost-Efficient** – Modular design, reusable components, no yearly fees
- 🔧 **Versatile Applications** – Supports development, testing, lab work and system engineering
- 🔧 **Simple, Powerful Design** – Compact footprint with high-quality, straightforward components



**HoPHiL**

**Test. Automation. Simplified.**

**Compact. Scalable. Powerful.**

## Example Use Cases:

### Basic Functionality

Relay-Card, Current/Voltage Measurements, CANFD communication,  
Ethernet/CANFD/RS232/DAC/ADC/PWM Gateways

### Extended Functionality

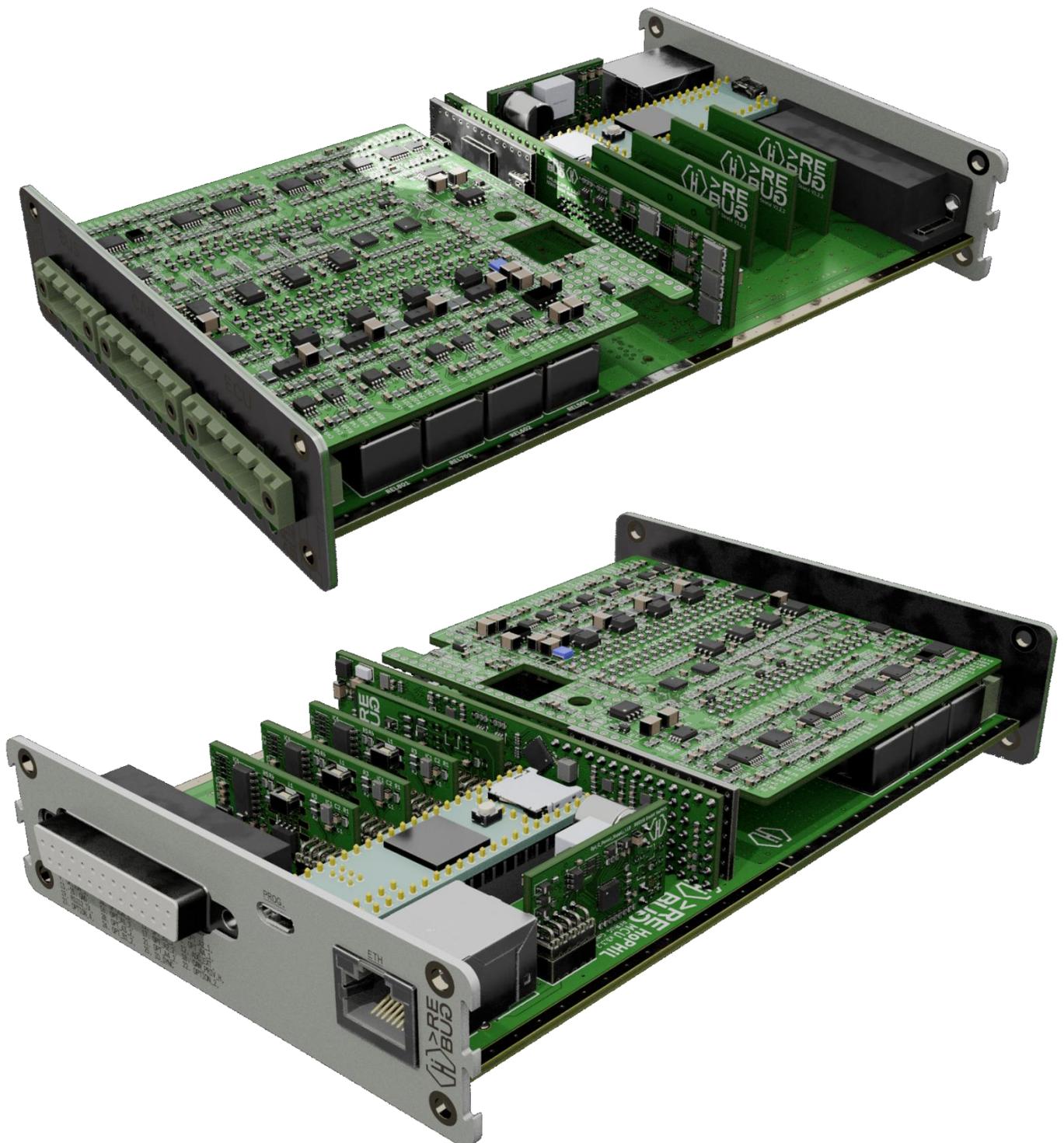
Real-time HiL Test equipment for safety & security testing with fault injection  
Advanced Break-Out-Box (HW Fault Injection)  
Current measurement and real time sensor simulation for closed loop testing  
Automatically generated CAN FD Rest Bus Simulation with E2E (Autosar Profiles)

### Expert Functionality

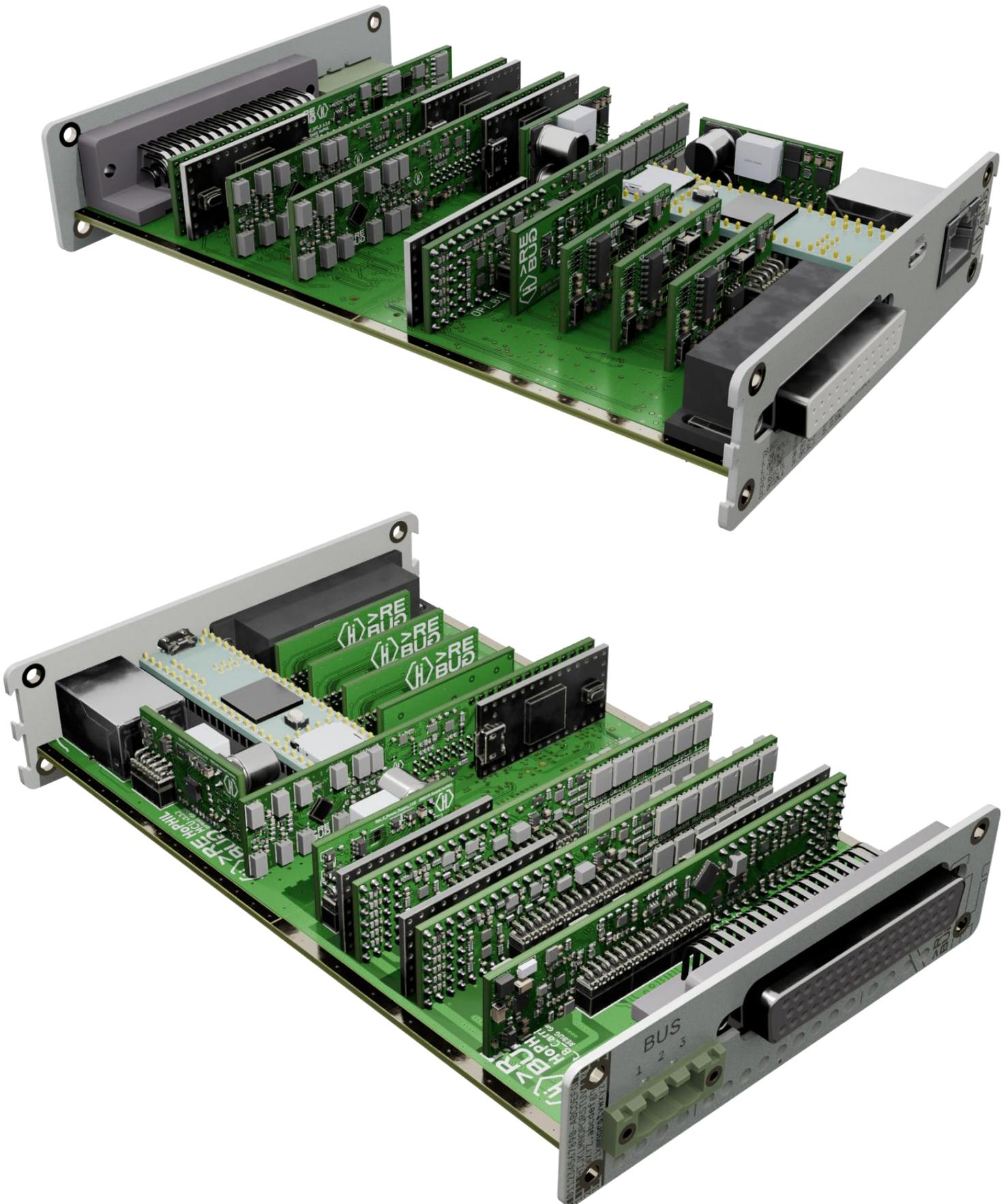
Environmental Simulation of Sensors, Loads, ECUs  
Cyber Security (SecOC Simulation, PEN/FUZZ/Attack Testing)  
ESX Virtual Machine support for easy cloning HiL Hosts  
Jenkins Continuous Integration and HiL Load Balancing  
In-Vehicle Safety & Security Testing with Fault Injection on Secured Content  
Visualization of CAR specific data (CAN FD, Sensor, XCP, UDS, LIN, ...) (Acquisition, Presentation)  
Autonomous Learning/Testing  
Autosar Time Synchronization Over CAN – ECU Synchronization & Time Acceptance Test + Fault Injection

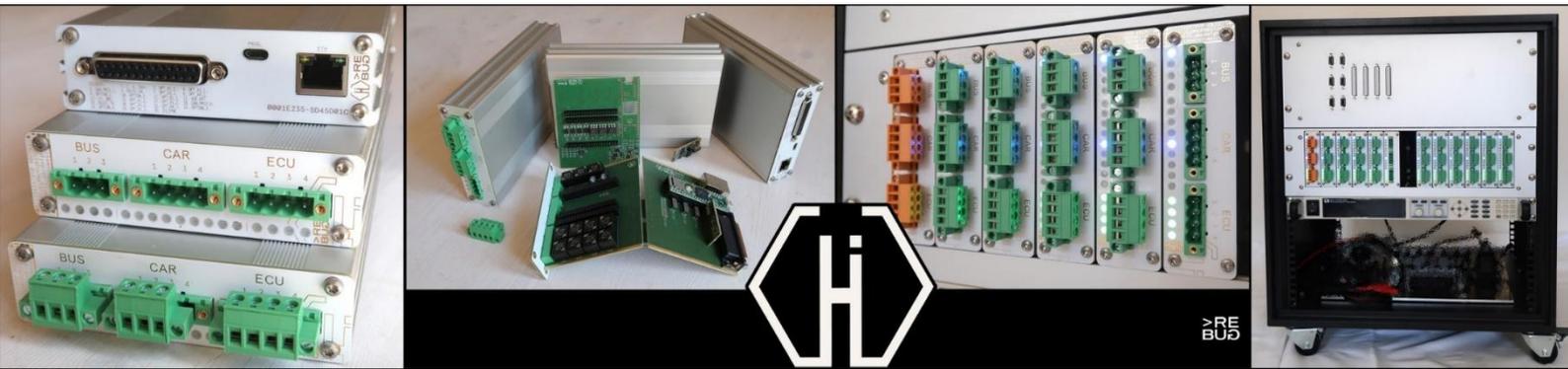
## HoPHiL Realtime Node – GEN3 (Hardware)

HoPHiL Fault Injection Unit for Environmental Simulation designed for Fault Injection



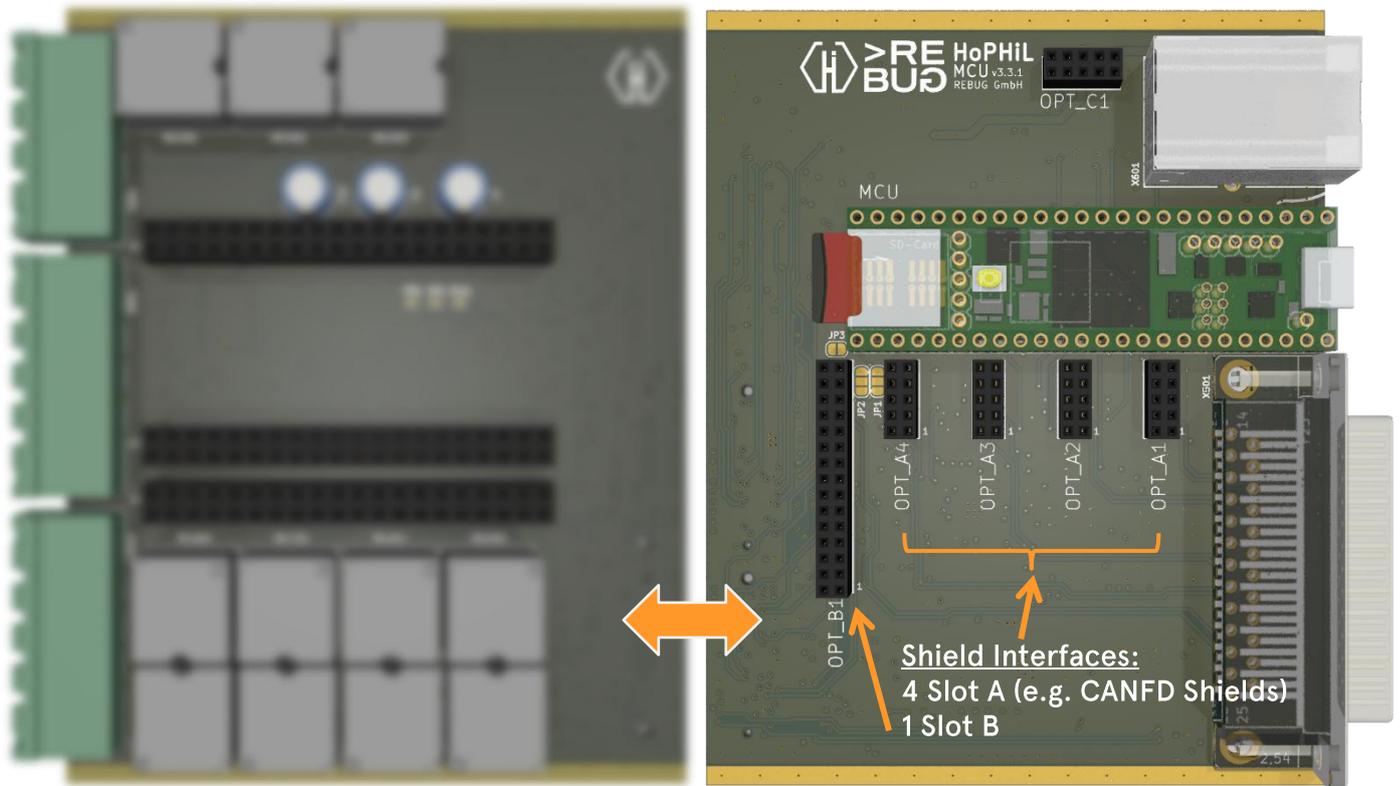
## More Flexibility with HoPHiL Carrier and OPT\_B Modules



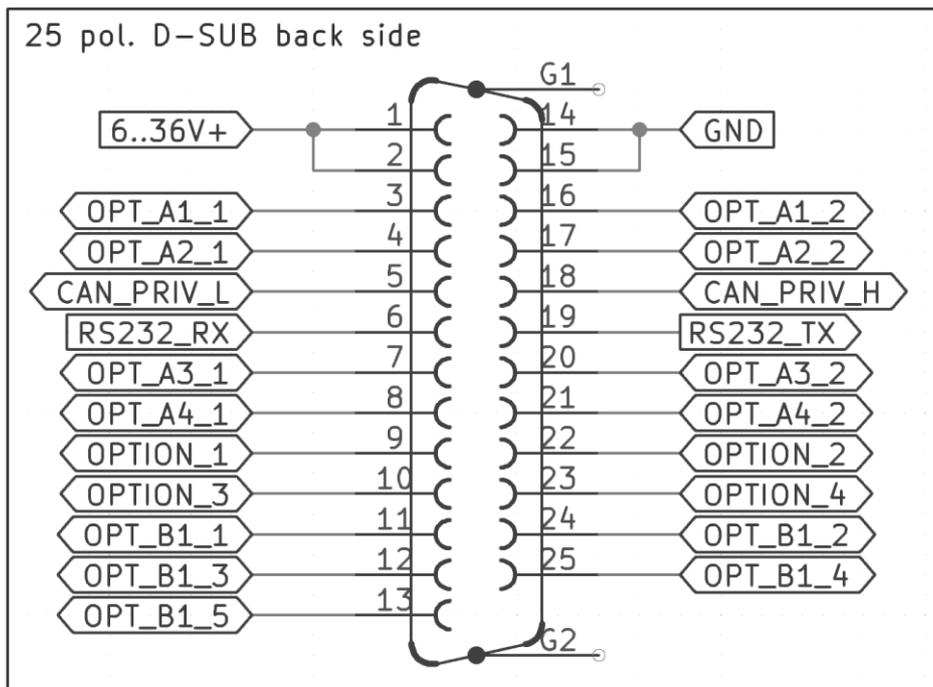


## MCU

Element	Details	Notes
Micro Controller	ARM Cortex-M7, 600 MHz	Passive cooling Firmware runs at a control-loop of 1ms cycle time
Remote Control	Ethernet 10/100 MBit/s or CANFD (limited functionality)	Ethernet is the main interface to control the device; CANFD Privileged is a second option to control the device (e.g. for integration to existing HiLs).
Plugs (rear side)	1x RJ45 (10/100 MBit/s) 1x DSUB25 1x USB Micro	RJ45 for main HW control interface DSUB25 is used for power supply, CANFD, RS232,... USB Micro for firmware update
SD Card Slot	1x	
CANFD Privileged	1x	Used for remote control, internal communication of several HoPHiLs or typical communication like Rest Bus Simulation, UDS, XCP
Slot OPT_Ax	4x SPI expansion slots (10 Pins) 2 IO-pins each on DSUB25	Up to 4 shields can be inserted - e.g. additional CANFD Channels.
Slot OPT_B1	1x Serial, I2C, SPI, CAN_PRIV expansion slot (30 Pins) 8 IO-pins on DSUB25	e.g. customer shield FIU_mini_Opt_B Pwr_DAC_Opt_B
Slot OPT_C1	1x I2C, power-supply expansion slot (10 pins)	Variable power-supply module required for FIU-Option, FIU-Shield and Power-DAC
RS232	1x	e.g. external power supply control
Housing	160 x 30 x 110mm (aluminum) V-Groove Mounting Concept	Typically delivered in one housing together with OPTION board (e.g. FIU_Option). V-Groove mounting via countersunk head screws.
Power Supply	6-36V	Useable in Vehicle with unstable 12V board net.

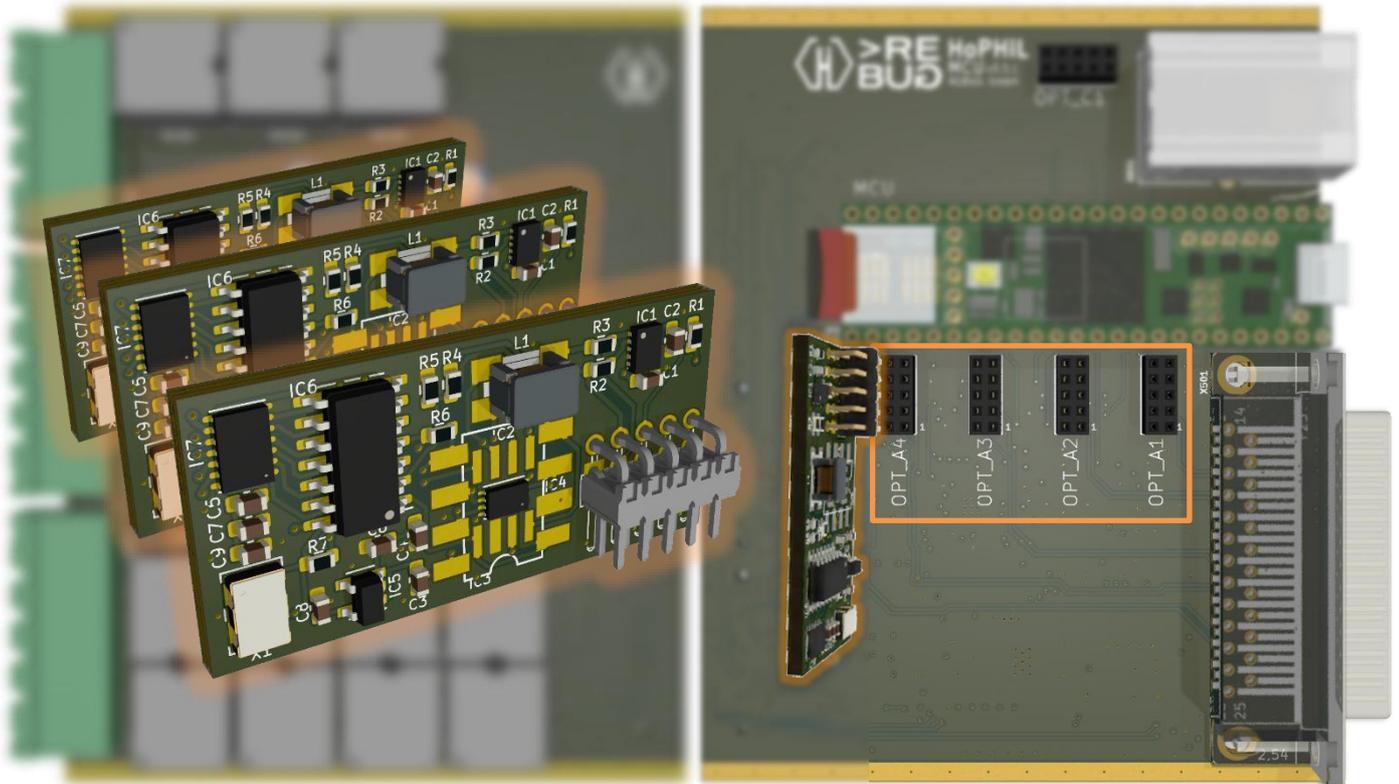


DSUB25 Pinout:

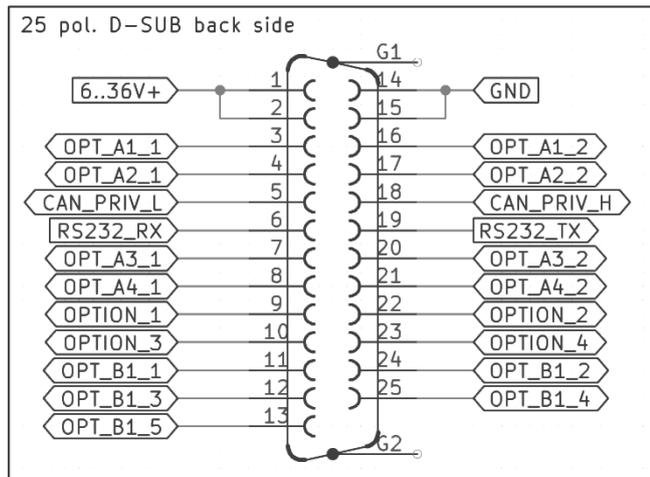


## CANFD Shield

Element	Details	Notes
CANFD	1x 40MHz CANFD channel	Used for e.g. RBS, XCP, UDS
Termination Resistor	120 Ohm	ON/OFF via software



CANFD H/L is mapped to the rear DSUB-25:



CANFD\_OPT\_A1 L -> OPT\_A1\_1  
 CANFD\_OPT\_A1 H -> OPT\_A1\_2

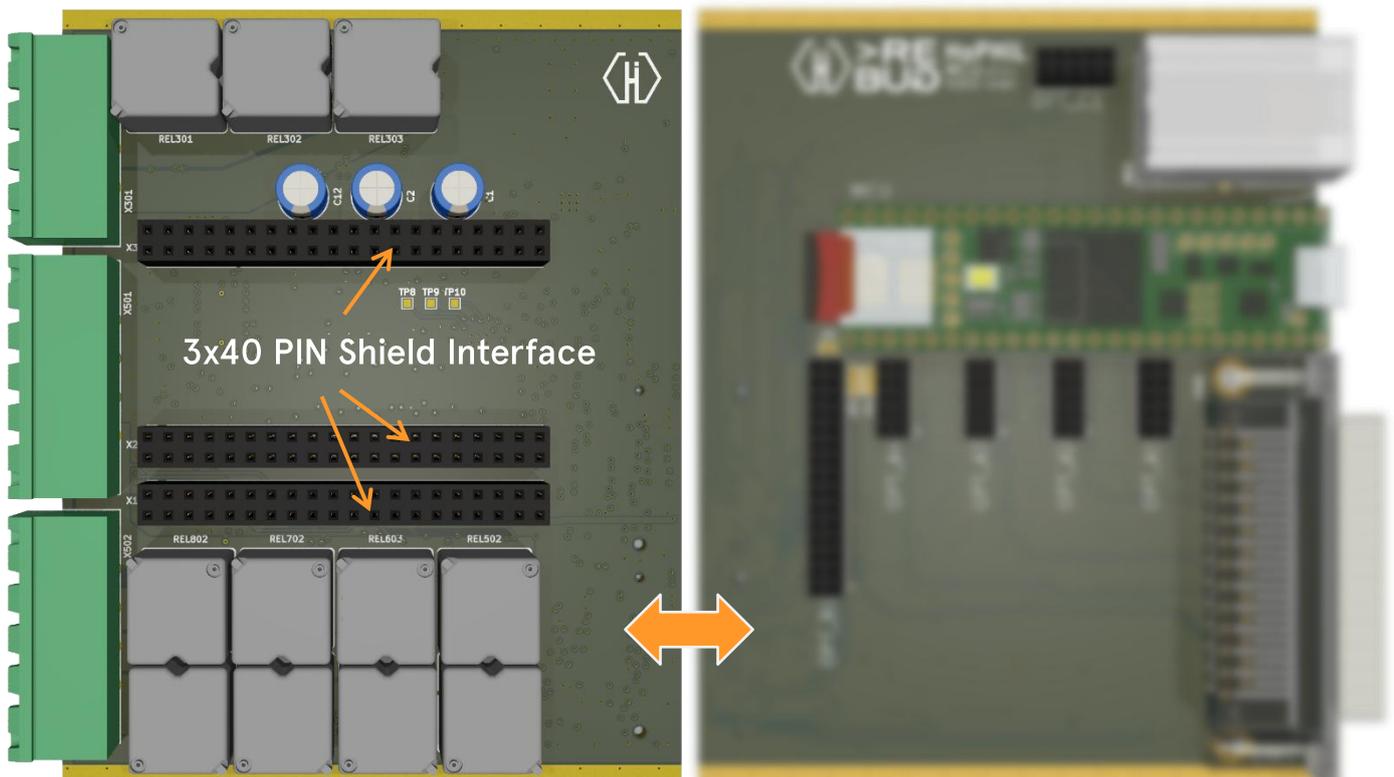
CANFD\_OPT\_A2 L -> OPT\_A2\_1  
 CANFD\_OPT\_A2 H -> OPT\_A2\_2

CANFD\_OPT\_A3 L -> OPT\_A3\_1  
 CANFD\_OPT\_A3 H -> OPT\_A3\_2

CANFD\_OPT\_A4 L -> OPT\_A4\_1  
 CANFD\_OPT\_A4 H -> OPT\_A4\_2

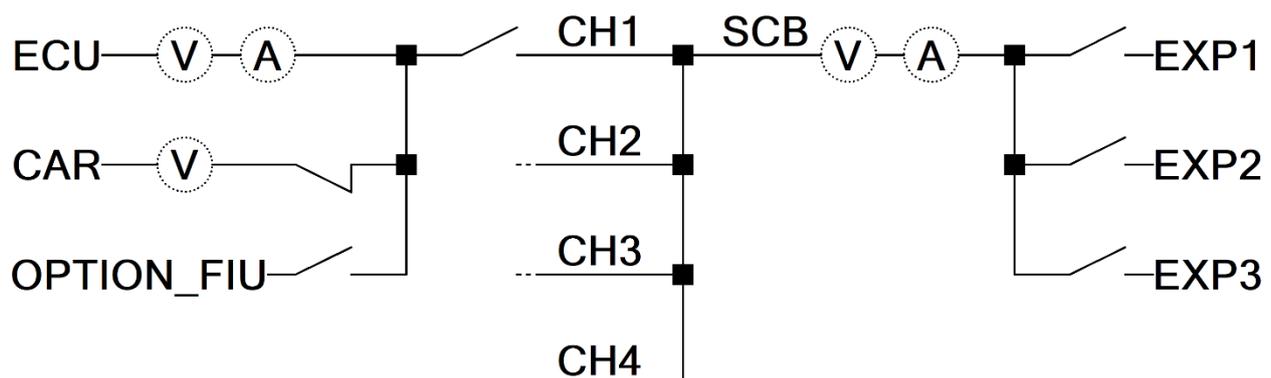
## FIU Option

Element	Details	Notes
Functionality	<ul style="list-style-type: none"> <li>• Open Line</li> <li>• Short to internal Short-Circuit-Bus (SCB)</li> <li>• Short between single channels</li> <li>• Short between multiple channels</li> <li>• Short of expansion bus (3x) to internal Short-Circuit-Bus</li> </ul>	<p>(Measurements and OPTION_FIU available with FIU-Shield)</p>
Channels	4	CAR Side / ECU Side (normally closed)
Internal Short Circuit Bus	1	Connect 1..n channels to internal short circuit bus to inject short circuit between channels or to expansion bus.
Expansion Buses	3	e.g. used for short to Clamp30, Clamp31 and external source or connect to other HoPHiL RT-Nodes and therefore create the possibility to short circuit channels of different RT-Nodes.
Max. current per channel	30A relays (25A opening, 30A closing) Up to 41A current measurement	see FIU Shield Type A
Expansion Slots	3 x 40 PIN expansion slots for advanced functionality.	see FIU Shield Type A



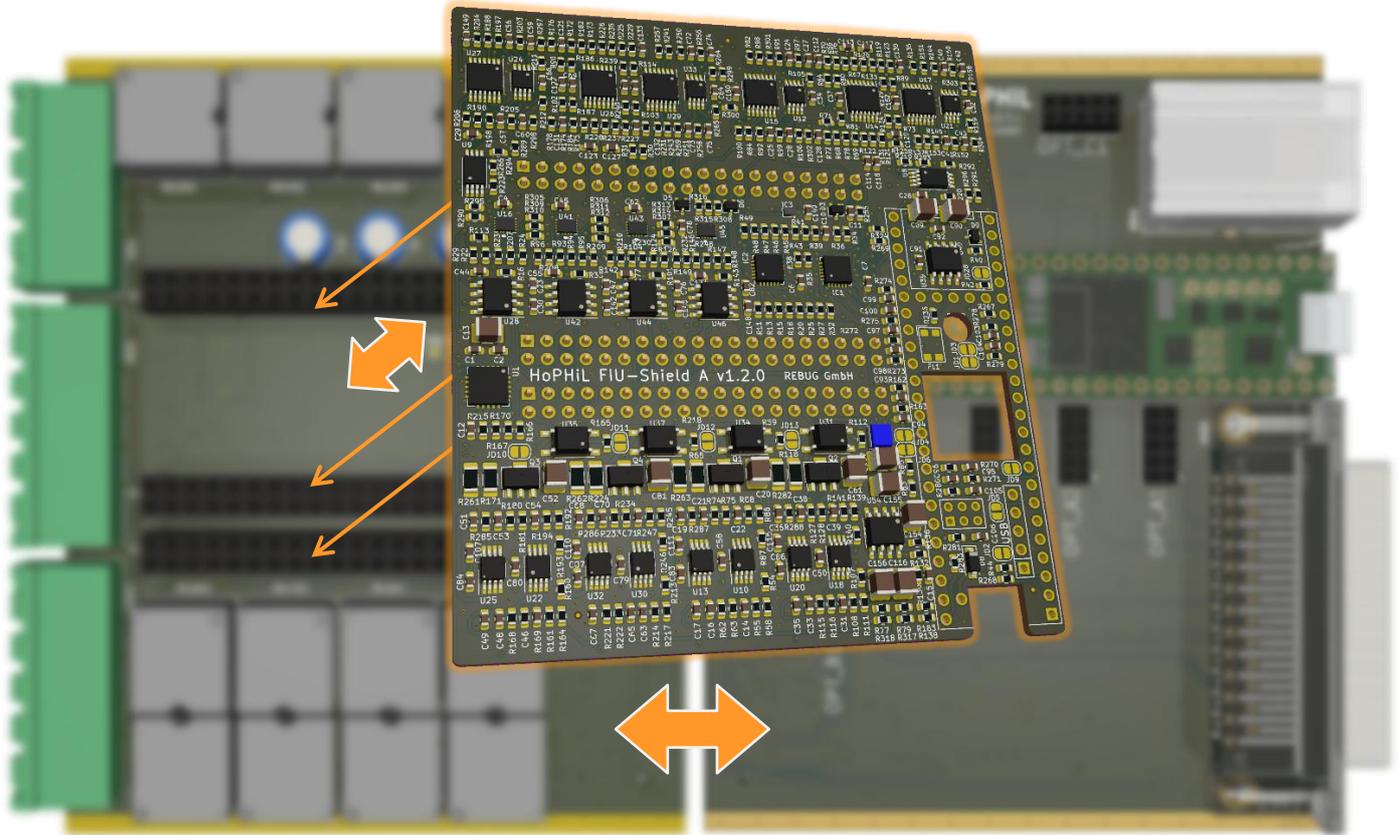
## FIU\_Shield\_Type\_A

Element	Details	Notes
Voltage Measurement CAR Side	+5V, +10V, +33V, $\pm 2.5V$ , $\pm 5V$ , $\pm 16.5V$ 12Bit DMA oversampled to 16Bit	
Voltage Measurement ECU Side	+5V, +10V, +33V, $\pm 2.5V$ , $\pm 5V$ , $\pm 16.5V$ 12Bit DMA oversampled to 16Bit	Short-Circuit-Bus has fixed range of -20V/+33V
Current Measurement	$\pm 2A$ , $\pm 5A$ , $\pm 10A$ , $\pm 25A$ , -1/+3A, -3/+1A, -2.5/+7.5A, -7.5/+2.5A, -5/+15A, -15/+5A, -13.75/+41.25A, -41.75/+13.75A 12Bit DMA oversampled to 16Bit	Short-Circuit-Bus has fixed range of -20A/+30A
Filter Depths	ADCs support various software-filter-types and -depths for each measurement to optimize for data-acquisition-speed vs noise-levels.	
Measurement Speed	900kSamples/s (~64 samples/1ms per measurement point e.g. voltage ECU side channel 1)	
DAC / PWM	4x (1x per channel) constant DAC 0-13V or 2 level PWM (low level 0-13V, high level 0-13V)	PWM levels are adjustable between 0-13V to simulate voltage or current based sensors.
MOSFET for EXP1..3	3x; 1.5A max	For bounce-free connection of all expansion buses to internal short circuit bus.
ECU Reboot Detection	Adjust threshold limits to detect a reboot (even Warm-Power-Resets) based on current-measurement.	Reboots are detected automatically and increase a reboot-counter.
Energy Consumption Protection	Protect device under test from being destroyed due to overcurrent/too high energy consumption.	If device under test consumes too much energy (including user-configurable cooling- rate assumptions) a safe reaction is performed to protect the connected device (channel is switched off).

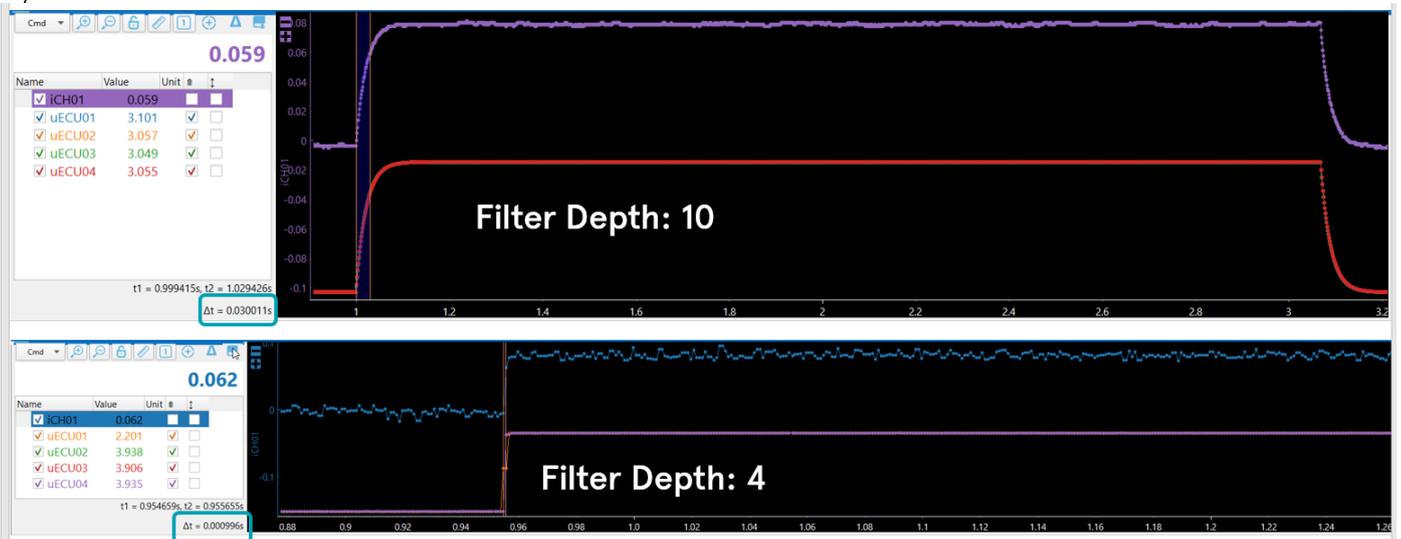


The FIU\_Shield\_Type\_A is inserted into the 3x40-pin slots. The MCU board performs ADC sampling and filtering of voltage and current measurements.

DAC/PWM signals are routed to the main FIU channels (ECU side) via analog switches and additionally to the OPTION\_1-4 pins of the rear DSUB25 connector through the MCU-OPT\_B connector. This enables internal use of the FIU\_Shield\_Type\_A DAC signals for fault injection on the FIU\_mini\_Opt\_B shield.



Adapt the filter depth to reduce noise or increase filter speed (e.g. 10ms vs 1ms filter) depending on your needs.



## FIU\_Opt\_B\_Carrier

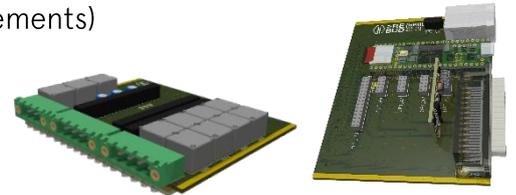
Element	Details	Notes
Functionality	<ul style="list-style-type: none"> <li>• 3 OPT_B shield slots (4 when paired w. MCU)</li> <li>• Individual SCBs (FIU_mini_Opt_B) switchable to 3 separate Expansion Buses EXP1..3</li> <li>• Short between single channels</li> <li>• Short between multiple channels</li> <li>• Short of expansion bus (3x) to internal Short-Circuit-Bus</li> </ul>	<p style="text-align: center;">(OPT_B1 expansion-slot on MCU) (SCB available with FIU_mini_Opt_B)</p>
Channels	<p>As per configuration</p> <p>e.g. 3x FIU_mini_Opt_B -&gt; 12 ECU/CAR channel-pairs (can be 24 independent analog inputs)</p> <p>e.g. 3x Pwr_DAC_Opt_B -&gt; 24 DAC-outputs</p> <p>e.g. 3x Pwr_DAC_Opt_B -&gt; 24 analog inputs</p>	<p>1 Additional OPT_B slot available on MCU, the Short-Circuit-Bus is routable into Opt_B_Carrier Expansion-Bus matrix as if part of carrier, primary channels go to rear-panel.</p>
Expansion Buses	<p>3 separate Buses connect any submodule-signals to each other or external sources;</p> <p>Any FIU_mini_Opt_B Short-Circuit-Bus can be connected to any Expansion Bus.</p>	<p>e.g. used for short to Clamp30, Clamp31 and external source / connect to further HoPHiL RT-Nodes and short-circuit channels of different RT-Nodes.</p>
Max. values EXP1..3 relays	<p>4,5A (9.5A 1ms 1-shot); ±40V; 0,02Ron</p>	<p>MOSFET-SSR for bounce-free connections</p>
OPT_B2-4 OPT_D1	<p>3 x 30 pin expansion slots for OPT_B</p> <p>1 x 65 pin expansion slot OPT_D</p>	<p>e.g. FIU_mini_Opt_B, Pwr_DAC_Opt_B</p> <p>e.g. additional functionalities</p>



## System Configuration Examples

### MCU, FIU\_Option, 1 x CANFD\_Shield:

- 4 ECU/CAR/SCB high-current FIU-channels (w/o measurements)
- 2 CANFD-channels
- 1 RS232
- Ethernet



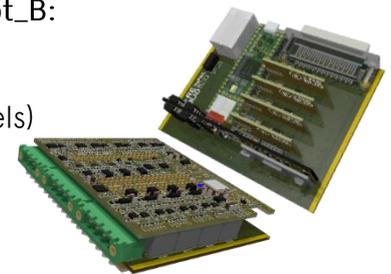
### MCU, FIU\_Option, FIU\_Shield\_Type\_A, 4 x CANFD\_Shield:

- 4 ECU/CAR/SCB high-current FIU-channels
- 4 DAC-channels (inject directly into ECU-side of FIU-channels)
- 5 CANFD-channels
- 1 RS232
- Ethernet



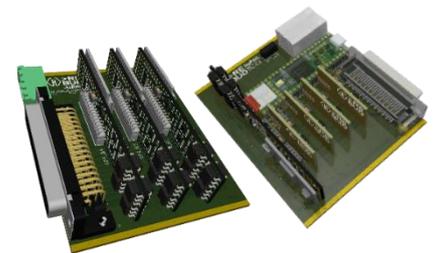
### MCU, FIU\_Option, FIU\_Shield\_Type\_A, 4 x CANFD\_Shield, 1 x FIU\_mini\_Opt\_B:

- 4 ECU/CAR/SCB high-current FIU-channels
- 4 ECU/CAR/SCB FIU-channels or 8 analog inputs
- 4 DAC/PWM-channels (inject directly into ECU-side of 8 FIU-channels)
- 5 CANFD-Channels
- 1 RS232
- Ethernet



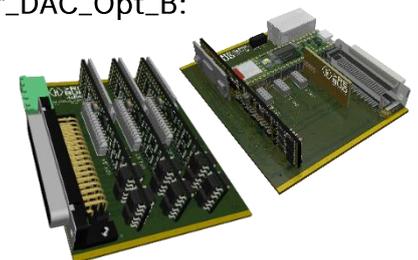
### MCU, FIU\_Opt\_B\_Carrier, 4 x CANFD\_Shield, 4 x FIU\_mini\_Opt\_B:

- 16 ECU/CAR/SCB FIU-channels or 32 analog inputs
- 5 CANFD-channels
- 1 RS232
- Ethernet



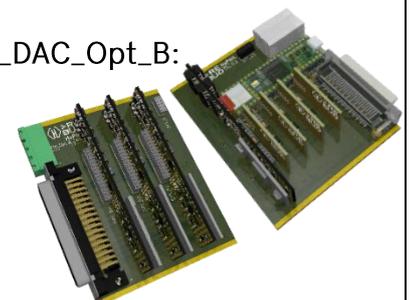
### MCU, FIU\_Opt\_B\_Carrier, 1 x CANFD\_Shield, 3 x FIU\_mini\_Opt\_B, 1 x Pwr\_DAC\_Opt\_B:

- 12 ECU/CAR/SCB FIU-channels or 24 analog inputs
- 4 high-current DAC-channels or 4 analog inputs (external routing)
- 4 low-current DAC-channels or 4 analog inputs (external routing)
- 2 CANFD-channels
- RS232
- Ethernet



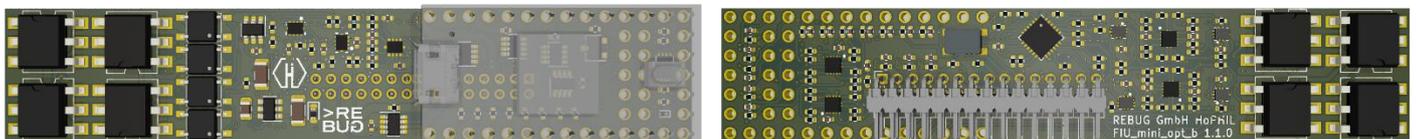
### MCU, FIU\_Opt\_B\_Carrier, 4 x CANFD\_Shield, 1 x FIU\_mini\_Opt\_B, 3 x Pwr\_DAC\_Opt\_B:

- 12 high-current DAC-channels or 12 analog inputs (external routing)
- 12 low-current DAC-channels or 12 analog inputs (external routing)
- 4 ECU/CAR/SCB FIU-channels or 8 analog inputs
- 5 CANFD-channels
- RS232
- Ethernet

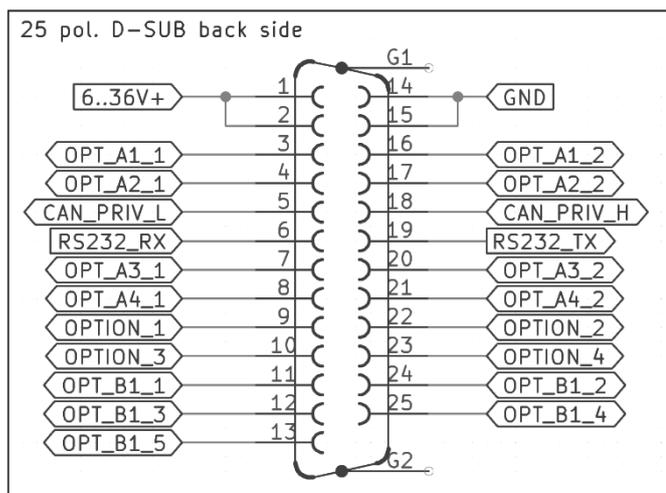


## FIU\_mini\_Opt\_B

Element	Details	Notes
Functionality	<ul style="list-style-type: none"> <li>• Open Line (normally open)</li> <li>• Short to internal Short-Circuit-Bus</li> <li>• Short between single channels</li> <li>• Short between multiple channels</li> <li>• Short of expansion bus (3x) to internal Short-Circuit-Bus (w. FIU_Opt_B_Carrier)</li> <li>• OPTION_FIU fault-injection per channel available with FIU_Shield_Type_A or FIU_Opt_B_Carrier</li> </ul>	<p>(EXP1..3 and OPTION_FIU with FIU_Opt_B_Carrier or FIU_Option)</p>
Channels	4	Open Line relay CAR/ECU normally open Alternatively, CAR/ECU sides can be utilized as separate analog inputs (x8; x9 in conjunction w. SCB-output on rear DSUB-25)
Internal Short Circuit Bus	1	Connect 1..n channels to internal short circuit bus to inject short circuit between channels or to expansion bus.



FIU\_mini\_Opt\_B Pinout OPT-B1 (on MCU):



FIU_mini_Opt_B	MCU
OPT_B1_ECU1	OPTION_1
OPT_B1_ECU2	OPTION_2
OPT_B1_ECU3	OPTION_3
OPT_B1_ECU4	OPTION_4
OPT_B1_CAR1	OPT_B1_1
OPT_B1_CAR2	OPT_B1_2
OPT_B1_CAR3	OPT_B1_3
OPT_B1_CAR4	OPT_B1_4
OPT_B1_SCB	OPT_B1_5
*) FIU_Opt_B_Carrier	
OPT_B1_OPTION_FIU1	OPTION_1 (DSUB-50)
OPT_B1_OPTION_FIU2	OPTION_2 (DSUB-50)
OPT_B1_OPTION_FIU3	OPTION_3 (DSUB-50)
OPT_B1_OPTION_FIU4	OPTION_4 (DSUB-50)

\*) In a configuration with FIU\_Shield\_Type\_A DAC/PWM-channels can be shared and routed internally into OPT B1 OPTION FIU1.4



Element	Details	Notes
Max. current channel relays	MOSFET-relays OL + SCB: 4,5A (9.5A 1ms 1-shot) (±40V; 0,02Ron) MOSFET-relays OPTION/FIU: 1,25A (3A 1ms 1-shot) (±40V; 0,15Ron)	
Voltage Measurement CAR Side	±16.5V, +33V, +16.5V 12Bit DMA oversampled to 16Bit	
Voltage Measurement ECU Side	±16.5V, +33V, +16.5V 12Bit DMA oversampled to 16Bit	Short-Circuit-Bus has fixed range of: -20/+33V
Current Measurement	±5A 12Bit DMA oversampled to 16Bit	On each channel located between ECU and other connections; On SCB located between channels and expansion buses
Filter Depths:	ADC-implementation supports various SW filter-types and depths to optimize for speed or noise-reduction.	
Measurement Speed	900kSamples/s (~64 samples/1ms per measurement-point e.g. voltage ECU side channel 1)	
Deployment options	MCU expansion slot OPT_B1 FIU_Opt_B_Carrier exp. slots OPT_B2..4 Communication via SPI and/or CAN_PRIV	By utilizing external CAN-bus control the shield can be used as standalone device (power-supply / packaging under development)

### FIU\_mini\_Opt\_B Pinout OPT\_B2..4 (on FIU\_Opt\_B\_Carrier):

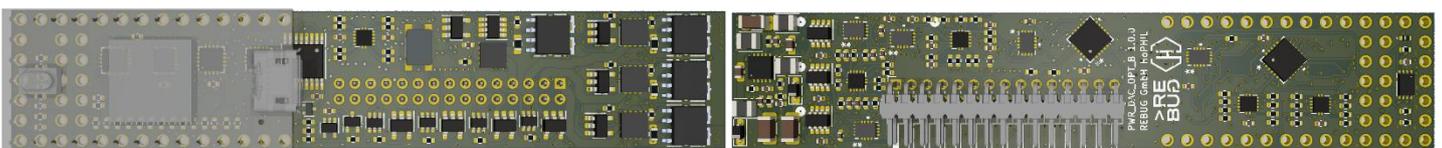
50P D-SUB front side	
OPT_B2_1	1
OPT_B2_2	2
OPT_B2_3	3
OPT_B2_4	4
OPT_B2_5	5
OPT_B2_6	6
OPT_B2_7	7
OPT_B2_8	8
OPT_B2_9	9
OPT_B2_10	10
OPT_B2_11	11
OPT_B2_12	12
OPT_B3_1	13
OPT_B3_2	14
OPT_B3_3	15
OPT_B3_4	16
OPT_B3_5	17
OPT_B3_6	18
OPT_B3_7	19
OPT_B3_8	20
OPT_B3_9	21
OPT_B3_10	22
OPT_B3_11	23
OPT_B3_12	24
OPT_B4_1	25
OPT_B4_2	26
27	OPT_B4_3
28	OPT_B4_4
29	OPT_B4_5
30	OPT_B4_6
31	OPT_B4_7
32	OPT_B4_8
33	OPT_B4_9
34	OPT_B4_10
35	OPT_B4_11
36	OPT_B4_12
37	OPTION_1
38	OPTION_2
39	OPTION_3
40	OPTION_4
41	OPT_D_1
42	OPT_D_2
43	OPT_D_3
44	OPT_D_4
45	OPT_D_5
46	OPT_D_6
47	OPT_D_7
48	OPT_D_8
49	OPT_D_9
50	OPT_D_10
51	
52	

FIU_mini_Opt_B	FIU_Opt_B_Carrier
OPT_Bn_ECU1	OPT_Bn_1
OPT_Bn_ECU2	OPT_Bn_2
OPT_Bn_ECU3	OPT_Bn_3
OPT_Bn_ECU4	OPT_Bn_4
OPT_Bn_CAR1	OPT_Bn_5
OPT_Bn_CAR2	OPT_Bn_6
OPT_Bn_CAR3	OPT_Bn_7
OPT_Bn_CAR4	OPT_Bn_8
OPT_Bn_OPTION_FIU1	OPT_Bn_9
OPT_Bn_OPTION_FIU2	OPT_Bn_10
OPT_Bn_OPTION_FIU3	OPT_Bn_11
OPT_Bn_OPTION_FIU4	OPT_Bn_12

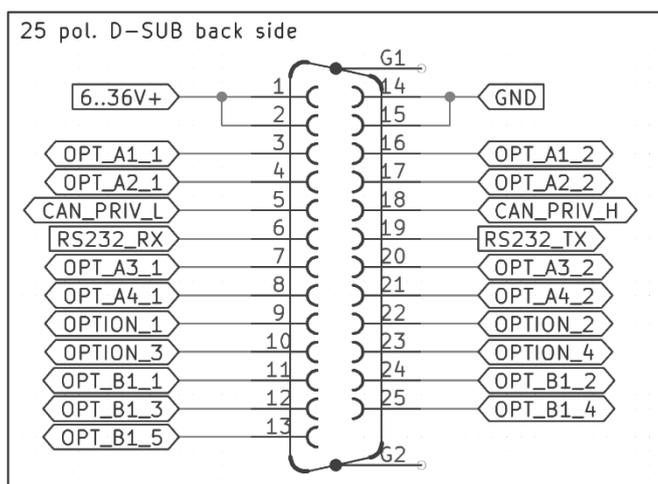


## Pwr\_DAC\_Opt\_B

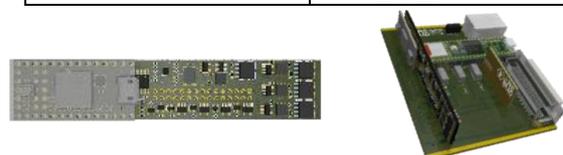
Element	Details	Notes
Functionality	4 high power DAC-channels 4 low power DAC-channels 8x voltage-measurement exposed to outside	Voltage measurements are performed on outside of the switches, enabling the use as separate analog inputs (x8).
High-power channels 1..4	<ul style="list-style-type: none"> <li>MOSFET-push-pull stage with PID-control</li> <li>DAC-output 12bit 0V..13V or 0V..24V</li> <li>5A DC (thermal limit); 10A pulse (&lt;1ms)</li> <li>Voltage-measurement (0V..25V)</li> <li>Current-measurement (-5.5A..+5.5A)</li> <li>Overcurrent-shutdown (switch opens)</li> </ul>	
Low-power channels 5..8	<ul style="list-style-type: none"> <li>DAC-output 12bit 0V..13V (independent of power-supply)</li> <li>50mA source/sink (short-circuit-capable)</li> <li>Voltage-measurement (0V..25V)</li> </ul>	
Max. current per channel	Ch1..4: $\pm 5A$ DC (thermal limits); 10A pulse (<1ms) Ch5..8: $\pm 50mA$ (short-circuit-capable)	Total power-dissipation is determined by system-configuration and can be minimized with variable power-supply.
Voltage-range (output)	0V..13V or 0V..24V	
Voltage-range (survival)	0V..40V	



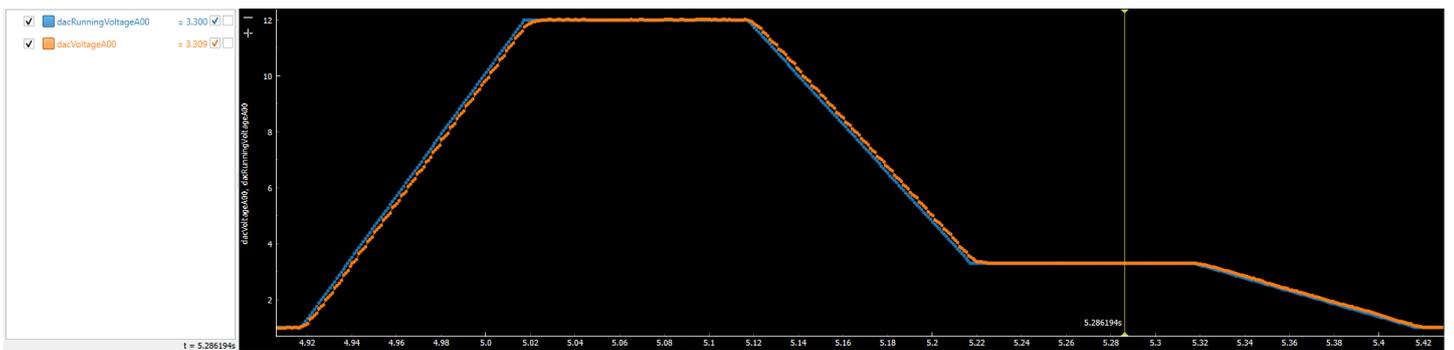
Pwr\_DAC\_Opt\_B Pinout (OPT\_B1 on MCU):



Pwr_DAC_Opt_B	MCU
CH1	OPTION_1
CH2	OPTION_2
CH3	OPTION_3
CH4	OPTION_4
CH5	OPT_B1_1
CH6	OPT_B1_2
CH7	OPT_B1_3
CH8	OPT_B1_4



Element	Details	Notes
Voltage Measurement	0V..25V on all channels 12Bit DMA oversampled to 16Bit	
Current Measurement	±5.5A (Ch1..4 only) 12Bit DMA oversampled to 16Bit	
Filter Depths:	ADC-implementation supports various filter-types and filter-depths to optimize for speed or noise-reduction.	
Measurement Speed	900kSamples/s (~64 samples/1ms per measurement-point e.g. voltage ECU side channel 1)	
Voltage-curves	User-configurable voltage-curves run in real-time at 1ms temporal resolution.	e.g. used for electric tests on supply voltages like voltage drops or brownout

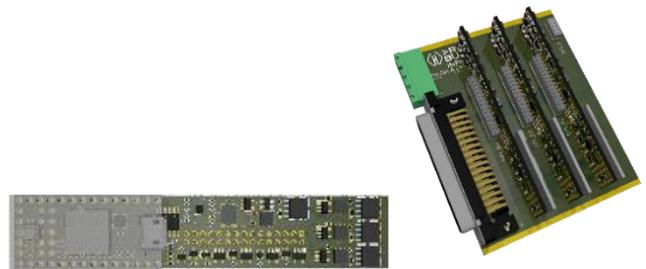


Pwr\_DAC\_Opt\_B Pinout (OPT\_B2..4 on FIU\_Opt\_B\_Carrier):

50P D-SUB front side

OPT_B2_1	1	27	OPT_B4_3
OPT_B2_2	2	28	OPT_B4_4
OPT_B2_3	3	29	OPT_B4_5
OPT_B2_4	4	30	OPT_B4_6
OPT_B2_5	5	31	OPT_B4_7
OPT_B2_6	6	32	OPT_B4_8
OPT_B2_7	7	33	OPT_B4_9
OPT_B2_8	8	34	OPT_B4_10
OPT_B2_9	9	35	OPT_B4_11
OPT_B2_10	10	36	OPT_B4_12
OPT_B2_11	11	37	OPTION_1
OPT_B2_12	12	38	OPTION_2
OPT_B3_1	13	39	OPTION_3
OPT_B3_2	14	40	OPTION_4
OPT_B3_3	15	41	OPT_D_1
OPT_B3_4	16	42	OPT_D_2
OPT_B3_5	17	43	OPT_D_3
OPT_B3_6	18	44	OPT_D_4
OPT_B3_7	19	45	OPT_D_5
OPT_B3_8	20	46	OPT_D_6
OPT_B3_9	21	47	OPT_D_7
OPT_B3_10	22	48	OPT_D_8
OPT_B3_11	23	49	OPT_D_9
OPT_B3_12	24	50	OPT_D_10
OPT_B4_1	25	51	
OPT_B4_2	26	52	

Pwr_DAC_Opt_B	FIU_Opt_B_Carrier
CH1	OPT_Bn_1
CH2	OPT_Bn_2
CH3	OPT_Bn_3
CH4	OPT_Bn_4
CH5	OPT_Bn_5
CH6	OPT_Bn_6
CH7	OPT_Bn_7
CH8	OPT_Bn_8

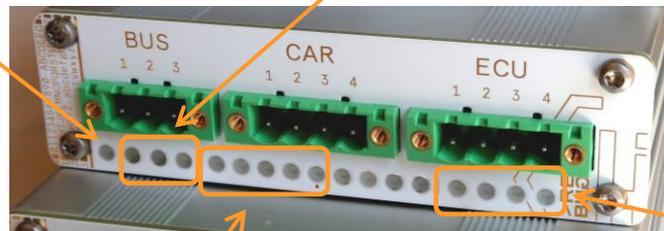


## LED Board

Element	Details	Notes
POWER LED	1x RGB LED	Status of internal voltage supply
STATUS LEDs	16x RGB LEDs	RGB – up to 8 states possible (color mapping see below)

POWER	5V	12V	15V BOOST	LED Color
	N	N	N	OFF
				X
				X
	Y	N	N	Blue
	Y	Y	N	Cyan
				X
				X
	Y	Y	Y	White

FIU Expansion BUS	RELAY	MOSFET	LED Color
	N	N	def.
			X
	Y	N	Red
		Y	Blue
			X
			X
	Y	Y	Magenta
			X

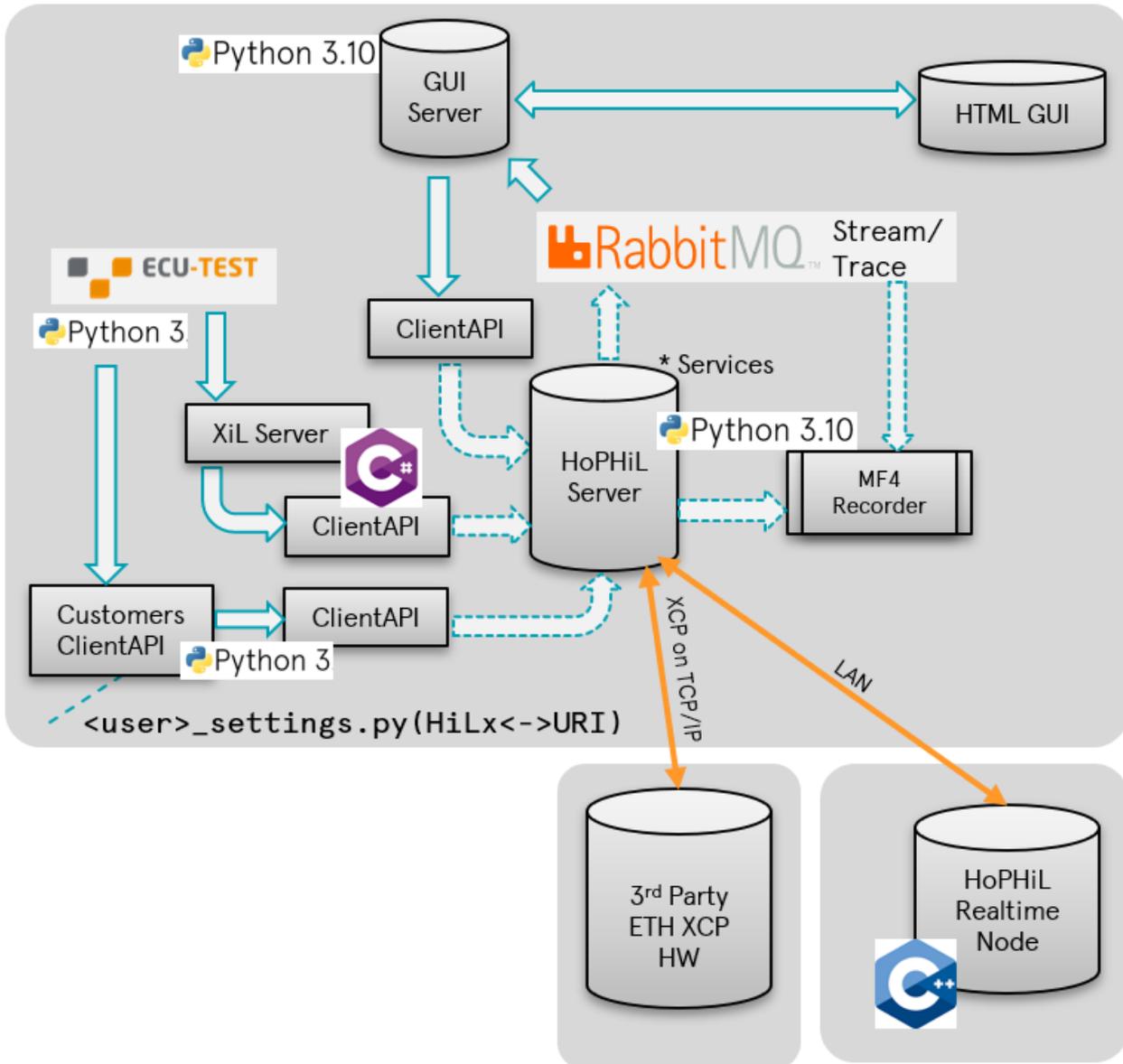


CAN 1-4, CAN_PRIV	TX	TX Error	RX	LED Color
	N	N	N	def.
	Y	N	N	Green
	N	Y	N	Red
	N	N	Y	Blue
	Y	N	Y	Cyan
	Y	Y	N	Yellow
	Y	Y	Y	Magenta
	Y	Y	Y	White

Colors and blink frequency depend on traffic amount.

FIU Channels	Connected	Open Line	SCB	DAC/PWM	LED Color
	Y	N	N	N	def.
	N	Y	N	N	Black
	N	Y	Y	N	Red
	N	Y	N	Y	Blue
	Y	N	N	Y	Cyan
	Y	N	Y	N	Yellow
	N	Y	Y	Y	Magenta
	Y	N	Y	Y	White

## HoPHiL Software, API and User Interface



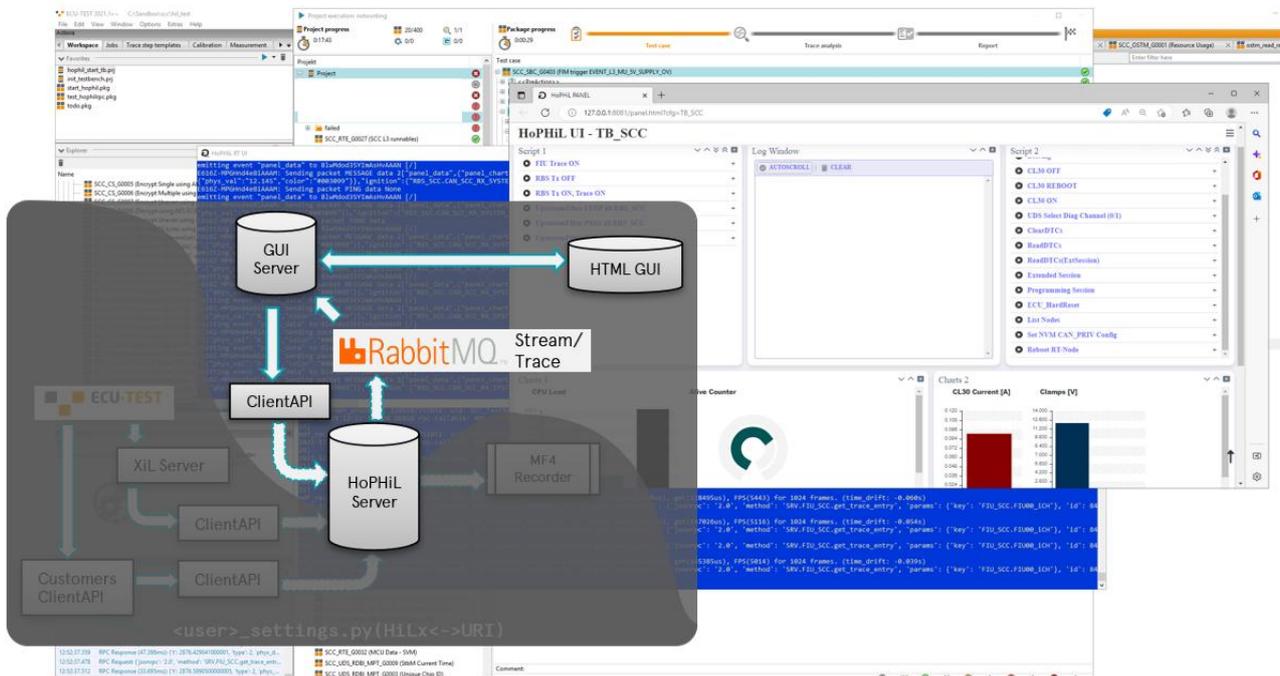
### Software Features

Element	Details	Notes
Architecture	<p>Service-based architecture:</p> <ul style="list-style-type: none"> <li>Service classes are RBS, UDS, XCP, FIU, RS232.</li> <li>Multiple instances of each service-type are supported.</li> </ul> <p>Client/Server architecture:</p>	

Element	Details	Notes
	<p>Allows to control each service from multiple clients at the same time.</p> <p>Open Source client API and Showcase Configuration</p>	
Client-API	<p>Python based Client-API to communicate to HoPHiL Server (PY 3.x) for full remote control functionality. Use as head-less system will ensure highest performance while full automation level is not limited.</p> <p>The integrated web based graphical user interface enables instant actions/analysis.</p> <p>The optional integration to  ECU Test is realized by the ASAM XiL interface.</p>	<p>e.g. parallel usage of native Python, Tracetronic ECU Test (XiL Server) and GUI is supported.</p>
Rest Bus Simulation (RBS)	<p>Full featured RBS is automatically generated from DBC or ARXML with the possibility to adapt configuration after loading.</p> <p>End2End protection (CRC and Alive Counter) supported: CRC J1850, H2F, AUTOSAR Profiles.</p> <p>Realtime Fault Injections on End2End and PDU based SecOC are supported.</p> <p>PDU based Cyber-Security SecOC is supported.</p> <p>Simulation Modes: ECU and Rest Bus</p>	
CANFD BUS Gateway	<p>“Man in the Middle” to forward or manipulate specific signals; Perform E2E or SecOC fault injections</p>	<p>Typically used for In-CAR testing or testing with multiple real ECUs in network. Single signals or signal groups can be manipulated while remaining are routed from real ECU.</p>
Cyber Security	<p>PDU based SecureOnboardCommunication (SecOC) including various fault injections and freshness synchronization.</p> <p>Deterministic execution, since CMAC and Freshness update are also performed on real-time hardware!</p>	

Element	Details	Notes
	Debug messages for easier SecOC failure analysis.  Secure Authentication via UDS enabled.	e.g. Daimler Zenzefi
RS232 Interface	For remote control of RS232 based devices (e.g. power supply)	
Unified Diagnostic Services (UDS)	Multiple diagnostic channels are supported per CAN Interface; CDD Database Support	
XCP	XCP over CANFD and XCP over Ethernet is supported. A2L database support	
FIU Control	All HW controls / measurements are available: <ul style="list-style-type: none"> <li>• Open Line,</li> <li>• Short between lines,</li> <li>• Expansion/Short Circuit Bus control</li> <li>• Voltage/Current measurement</li> <li>• DAC/PWM control</li> <li>• Voltage/Current Range selection</li> <li>• Calibration of measurements</li> </ul>	
Recording	ASAM MF4 based recording file	Usage of various filtering concepts (trace, decode and recording) to save CPU resources. UDS Requests including DTCs are part of recording.
MF4 Viewer	ASAM-MDF viewer to analyze mf4 files visually	
Continuous Testing / Continuous Integration 	HoPHiL is designed and tested to be integrated in Jenkins and VMWare ESXi.  We also offer an integration to Jenkins via our load balancing pipeline scripts.	Use load balancing to all available test systems (HiLs) to run a regression test within a much shorter time!

# Graphical User Interface (GUI)



## HTML Based GUI

Element	Details	Notes
GUI	Web-UI accessed by Web Browser	GUI can be connected/disconnected at any time to running services. Disconnect to save CPU resources while regression test is performed.
Views	<p>Message Monitoring See RX/TX frames, PDUs and signals including interval times, min/max values. The table overview allows to configure signals to specific cells.</p> <p>Panel View Control via individual command scripts (python based) and log them in dialog. Visualize via gauge, bar charts and interactive schematics.</p> <p>Sequential Trace Sequential view of selected messages/frames.</p> <p>Offline Signal Viewer Open .mf4 files for offline analysis of the recorded signals</p>	

## Message Monitoring

### Overview Example

#### HoPHiL UI - Showcase\_Project

##### SIGNAL MONIT

#	Signal Name	Value	Min Value	Max Value
1	..Data00.CSD0_FreshnessFull1_01			
2	..Data00.CSD0_FreshnessInc_01			
3				
4	..ONCASE.V_DEM_SystemUpCounter			
5				
6				
7				
8				
9				
10				

#	Signal Name	Value	Min Value	Max Value
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

#	Signal Name	Value	Min Value	Max Value
1	FIU_SHOWCASE.FIU00_Ich.ICH01	-0.0...	-0.026	-0.017
2	.._SHOWCASE.FIU00_uECU.uECU01	1.515	1.509	1.517
3	.._SHOWCASE.FIU00_uECU.uECU02	1.520	1.512	1.523
4	.._SHOWCASE.FIU00_uECU.uECU03	1.518	1.509	1.521
5	.._SHOWCASE.FIU00_uECU.uECU04	1.506	1.505	1.508
6				
7	..otCounter.rebootCounterCH00	0.000	0.000	0.000
8				
9				
10				

##### MESSAGE MONITORING

Trace	Hide/Show	Service	ID	PDU Ty...	PDU Name	Interv...	Min ...	Max I...	Dir...	Payload																									
<input type="checkbox"/>	<input checked="" type="checkbox"/>	INTERNAL_VCANFD_S...	0x1FFFFFF0	SIGNAL	CybSecData00	200.00	199.97	200.03	TX	00 00 00 00 00 00 00 00 0C 0A 00 00 00 00 00 00 00 00 00 00 01 0...																									
<input type="checkbox"/>	<input checked="" type="checkbox"/>	RBS_1_SHOWCASE	0x22	SIGNAL	ECU_2_TX_Msg_2	20.00	19.97	20.03	TXERR	98 04 00 00 00 00 00																									
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Signal Name</th> <th>Physical Va...</th> <th>Raw Value</th> <th>Min Value</th> <th>Max Value</th> </tr> </thead> <tbody> <tr><td><input type="checkbox"/></td><td>CRC_VIPsignals</td><td>152</td><td>152</td><td>18</td></tr> <tr><td><input type="checkbox"/></td><td>ALIVE_VIPsignals</td><td>4</td><td>4</td><td>15</td></tr> <tr><td><input type="checkbox"/></td><td>ECU_2_Sig_22</td><td>Default Value</td><td>Default Value</td><td>Default Value</td></tr> <tr><td><input type="checkbox"/></td><td>ECU_2_Sig_21</td><td>0</td><td>0</td><td>0</td></tr> </tbody> </table>											Signal Name	Physical Va...	Raw Value	Min Value	Max Value	<input type="checkbox"/>	CRC_VIPsignals	152	152	18	<input type="checkbox"/>	ALIVE_VIPsignals	4	4	15	<input type="checkbox"/>	ECU_2_Sig_22	Default Value	Default Value	Default Value	<input type="checkbox"/>	ECU_2_Sig_21	0	0	0
Signal Name	Physical Va...	Raw Value	Min Value	Max Value																															
<input type="checkbox"/>	CRC_VIPsignals	152	152	18																															
<input type="checkbox"/>	ALIVE_VIPsignals	4	4	15																															
<input type="checkbox"/>	ECU_2_Sig_22	Default Value	Default Value	Default Value																															
<input type="checkbox"/>	ECU_2_Sig_21	0	0	0																															
<input type="checkbox"/>	<input checked="" type="checkbox"/>	RBS_1_SHOWCASE	0x10	SIGNAL	Example_Msg_01	20.00	19.92	20.08	TXERR	E2 03 00 00 00 00 00																									
<input type="checkbox"/>	<input checked="" type="checkbox"/>	FIU_SHOWCASE	0x402	SIGNAL	FIU00_Ich	10.02	9.94	10.06	RX	F0 7F F0 7F E3 7F EF 7F																									
<input type="checkbox"/>	<input checked="" type="checkbox"/>	FIU_SHOWCASE	0x403	SIGNAL	FIU00_Status	20.00	19.96	20.04	RX	00 00 00 02 51 23 03 00																									
<input type="checkbox"/>	<input checked="" type="checkbox"/>	FIU_SHOWCASE	0x401	SIGNAL	FIU00_uCAR	80.00	79.96	80.04	RX	EA 85 E9 85 E6 85 E2 85																									
<input type="checkbox"/>	<input checked="" type="checkbox"/>	FIU_SHOWCASE	0x400	SIGNAL	FIU00_uECU	10.02	9.95	10.06	RX	EB 85 F0 85 EE 85 E3 85																									
<input type="checkbox"/>	<input checked="" type="checkbox"/>	FIU_EXT_SHOWCASE	0x407	SIGNAL	FIU01_Ich	9.99	0.00	8981.01	RX	01 00 03 80 02 80 00 80																									
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Signal Name</th> <th>Physical Va...</th> <th>Raw Value</th> <th>Min Value</th> <th>Max Value</th> </tr> </thead> <tbody> <tr><td><input type="checkbox"/></td><td>ICH04</td><td>0</td><td>32768</td><td>-0.001249999999...</td></tr> <tr><td><input type="checkbox"/></td><td>ICH03</td><td>0.002499999999...</td><td>32770</td><td>0</td></tr> <tr><td><input type="checkbox"/></td><td>ICH02</td><td>0.003749999999...</td><td>32771</td><td>0</td></tr> <tr><td><input type="checkbox"/></td><td>ICH01</td><td>0.001249999999...</td><td>32769</td><td>0</td></tr> </tbody> </table>											Signal Name	Physical Va...	Raw Value	Min Value	Max Value	<input type="checkbox"/>	ICH04	0	32768	-0.001249999999...	<input type="checkbox"/>	ICH03	0.002499999999...	32770	0	<input type="checkbox"/>	ICH02	0.003749999999...	32771	0	<input type="checkbox"/>	ICH01	0.001249999999...	32769	0
Signal Name	Physical Va...	Raw Value	Min Value	Max Value																															
<input type="checkbox"/>	ICH04	0	32768	-0.001249999999...																															
<input type="checkbox"/>	ICH03	0.002499999999...	32770	0																															
<input type="checkbox"/>	ICH02	0.003749999999...	32771	0																															
<input type="checkbox"/>	ICH01	0.001249999999...	32769	0																															
<input type="checkbox"/>	<input checked="" type="checkbox"/>	FIU_EXT_SHOWCASE	0x408	SIGNAL	FIU01_Status	20.00	8.97	8991.03	RX	00 00 00 24 6C 00 80 80																									
<input type="checkbox"/>	<input checked="" type="checkbox"/>	FIU_EXT_SHOWCASE	0x406	SIGNAL	FIU01_uCAR	80.00	69.99	9050.01	RX	17 00 1A 80 F5 7F F5 7F																									



# Panel View

## Overview Example

HoPHiL UI - Showcase\_Project

**PANEL**

- HoPHiL
- > XCP
- > UDS Control
- > UDS Request
- > PwrDAC Control
  - PwrDAC Connect Channel
  - PwrDAC Disconnect Channel
  - PwrDAC Set Voltage On Channel
  - PwrDAC Assign List To Channel
  - PwrDAC Play List On Channels
  - PwrDAC Stop List On Channels
  - PwrDAC Pause List On Channels
  - Display All Available List Configurations
  - Update List Configuration
  - Clear List Configuration
  - Display Latest Loaded Lists
  - PwrDAC Get Voltage For Channel
  - PwrDAC Get Current For Channel

**Output**

COMPLETED (2 elements)

```

12.2.2024, 12:17:14 PwrDAC Play List On Channels:
12.2.2024, 12:17:14 PwrDAC Play List On Channels: Done
          
```

**ECU under test**

- > Test Cases
  - Start Manual Test
  - Stop Manual Test
- > ECU Control
- > Clamps
- > Power Supply

**some example data**

Speeds (input)

Direction (1=Forward/2=Reverse)

**ECU Control**

CL30 Current [A]

Clamp Voltage [V]

Ignition

CRC\_Alive\_Chart

CRC\_Alive\_Chart\_slow

Ignition On/Off

**HoPHiL RT-Node(FIU/PwrDAC)**

**Node 1**

**Node 2**

**Possible Elements**

Uniform Bar Chart ECU

Bar Chart CL30

Graph ECU fast

Graph ECU slow

Graph CL slow

Graph CL15 fast

Graph CL15 slow

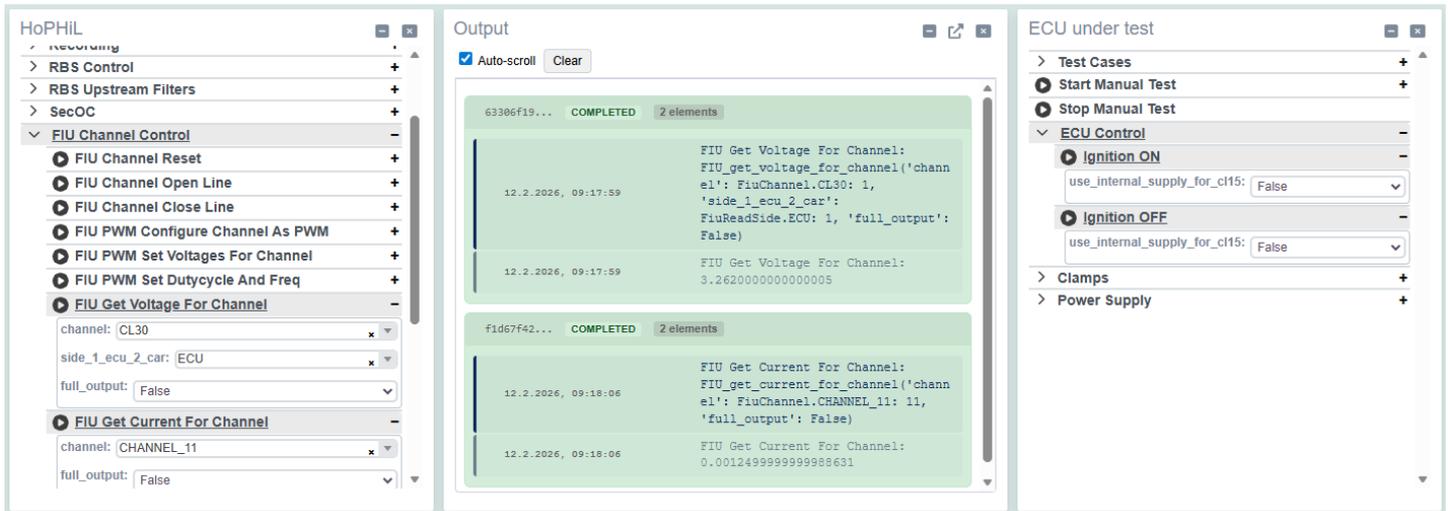
Enum Chart with Signs

REBUG GmbH

HoPHiL - Realtime Node - GEN3

- 22 -

## Action Container and Logging



The screenshot displays the HoPHiL interface with three main panels:

- HoPHiL (Action Container):** A tree view on the left showing various actions like 'FIU Channel Control', 'FIU Channel Reset', 'FIU Channel Open Line', etc. The 'FIU Get Voltage For Channel' action is selected, showing configuration options for channel (CL30), side\_1\_ecu\_2\_car (ECU), and full\_output (False).
- Output:** A central panel showing the execution results of the selected action. It displays two log entries with timestamps (12.2.2026, 09:17:59) and their corresponding JSON-like output data.
- ECU under test:** A panel on the right showing test cases and controls, including 'Ignition ON' and 'Ignition OFF' buttons, and 'Clamps' and 'Power Supply' sections.

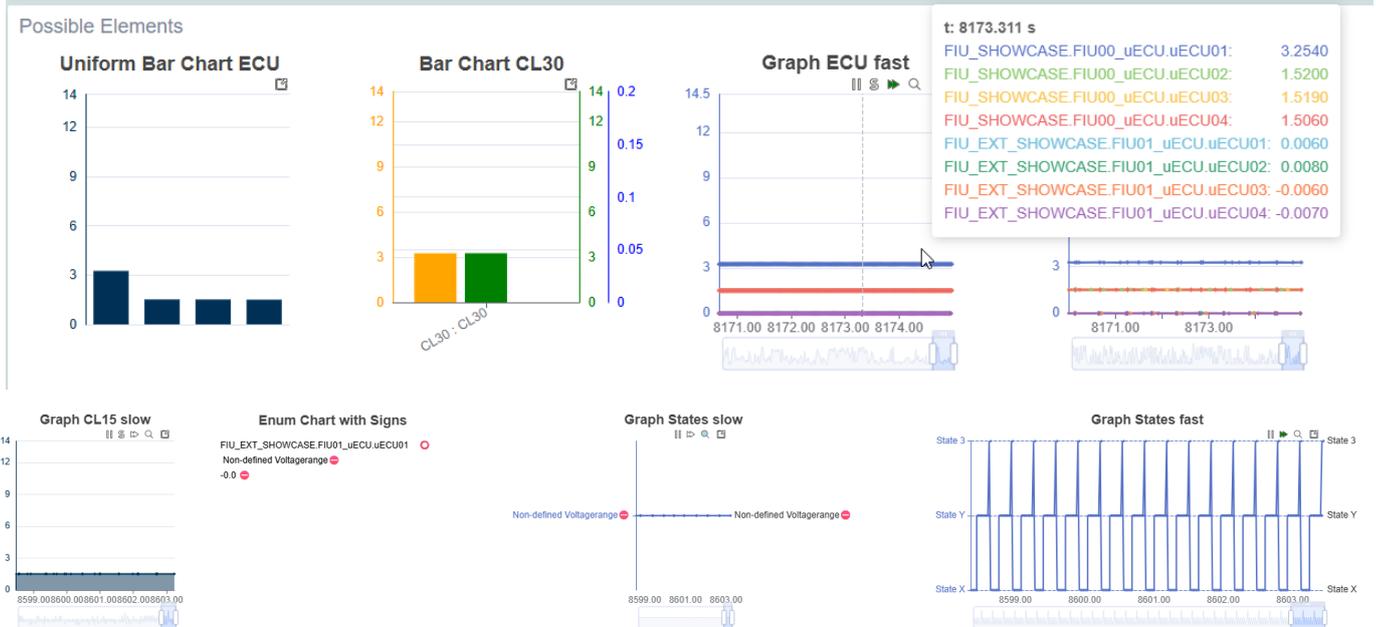
Element	Description	Details
Action Container	The left action container offers generic HoPHiL actions while the right container is typically used for customer/project specific actions.	<ul style="list-style-type: none"> <li>- dynamically populated dropdown (while runtime)</li> <li>- interdependent and cascading dropdowns</li> <li>- Default Argument Values</li> <li>- None-able arguments</li> </ul> ⇒ Easy add/remove/adapt interfaces via Python 🐍
Output	Detailed output of Actions and logging history	<ul style="list-style-type: none"> <li>- Raw Value in Hex,</li> <li>- Physical Value</li> <li>- Min/Max Value</li> </ul>

## Graphs and Graph Container

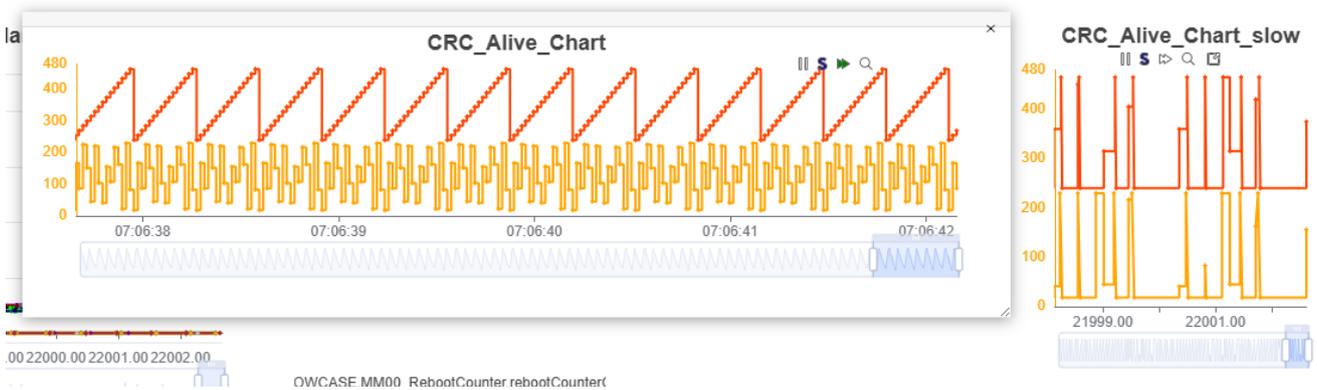
### Graph Container



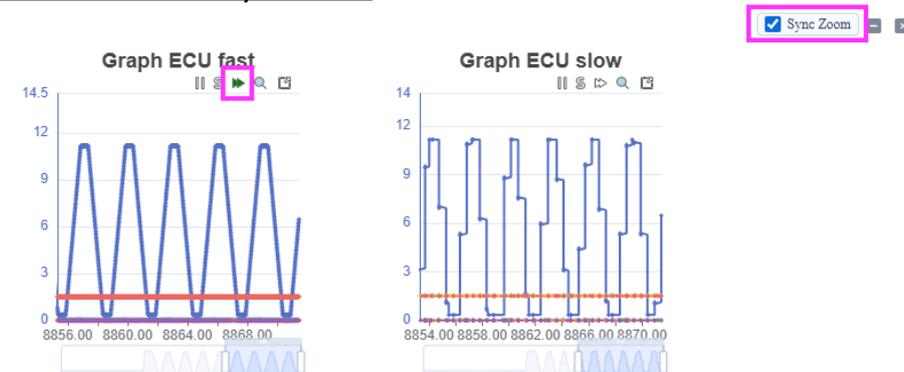
### Graph Types



### Popout

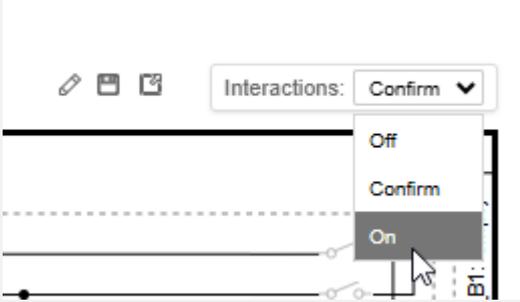


### Realtime View and Sync Zoom



Element	Description	Details
Graph Container	Web Container containing a single or multiple graphs.	Adapt size  Collapse or close containers  
Graph Types	Various Graph types are supported: <ul style="list-style-type: none"> <li>- Bar Charts</li> <li>- Gauge</li> <li>- Line Charts</li> <li>- Stacked Line Chart</li> <li>- State Charts</li> <li>- Enum Charts</li> </ul>	Graph Features: <ul style="list-style-type: none"> <li>- X/Y Zoom </li> <li>- Multiple Y axes</li> <li>- Hover information to see signals and values</li> <li>- Pause charts  for better analysis</li> <li>- Stacking of signals </li> </ul>
Popout 	Popout one specific chart	Get a better overview – popout and expand the graph chart. Move it to other positions to compare e.g. with interactive schematics. Popped out charts support all graph features.
Realtime View 	Enable realtime or resource optimized view.	Enable realtime view to see each signal value over time or disable to get the resource optimized view to save CPU Load. Min/Max/Average values are still shown in this mode.
Sync View 	Synchronize Zoom (Factor and Range)	Same zoom factor and zoom range are used across all graphs within a graph container.



Element	Description	Details
Live View	Enhance usability in complex systems by combining schematics or images with live signal data and interactive hardware switching control.	<p>Place measurement signals to display real-time values and switches to visualize their open/closed state. Hovering over an element reveals the source signal and its alias name.</p> <p>Change the state of a switch by clicking on it.</p> <p>To configure the interaction behavior, specify whether confirmation is required or disable interaction entirely.</p> 
Edit View 	Graphically configure the position of signal data and switches using overlays.	Use Cursor to move the overlay or change value in dialog form. Use the "Repositioning of Group" Feature to move all overlays by the given x/y offset of first moved overlay.
HoPHiL Library	Create system views quickly and easily using our HoPHiL schematics library.	<p>Our HoPHiL schematics graphics library is based on the free Web Vector graphics tool DrawIO. Export the final schematics as vector graphics like .svg to ensure lossless scaling without quality degradation.</p> 

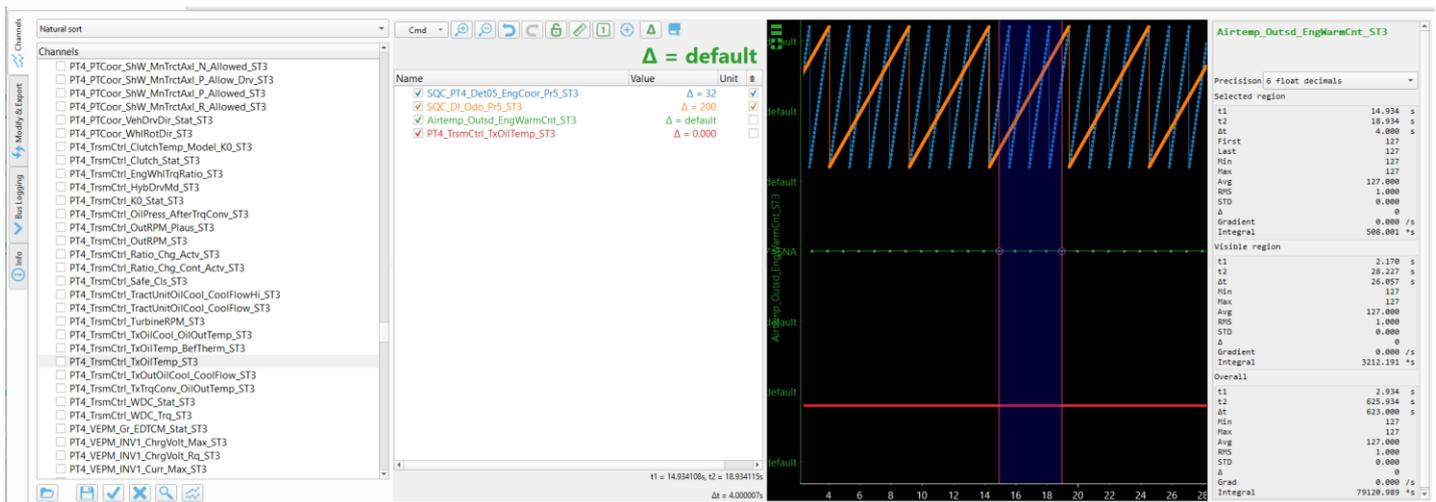
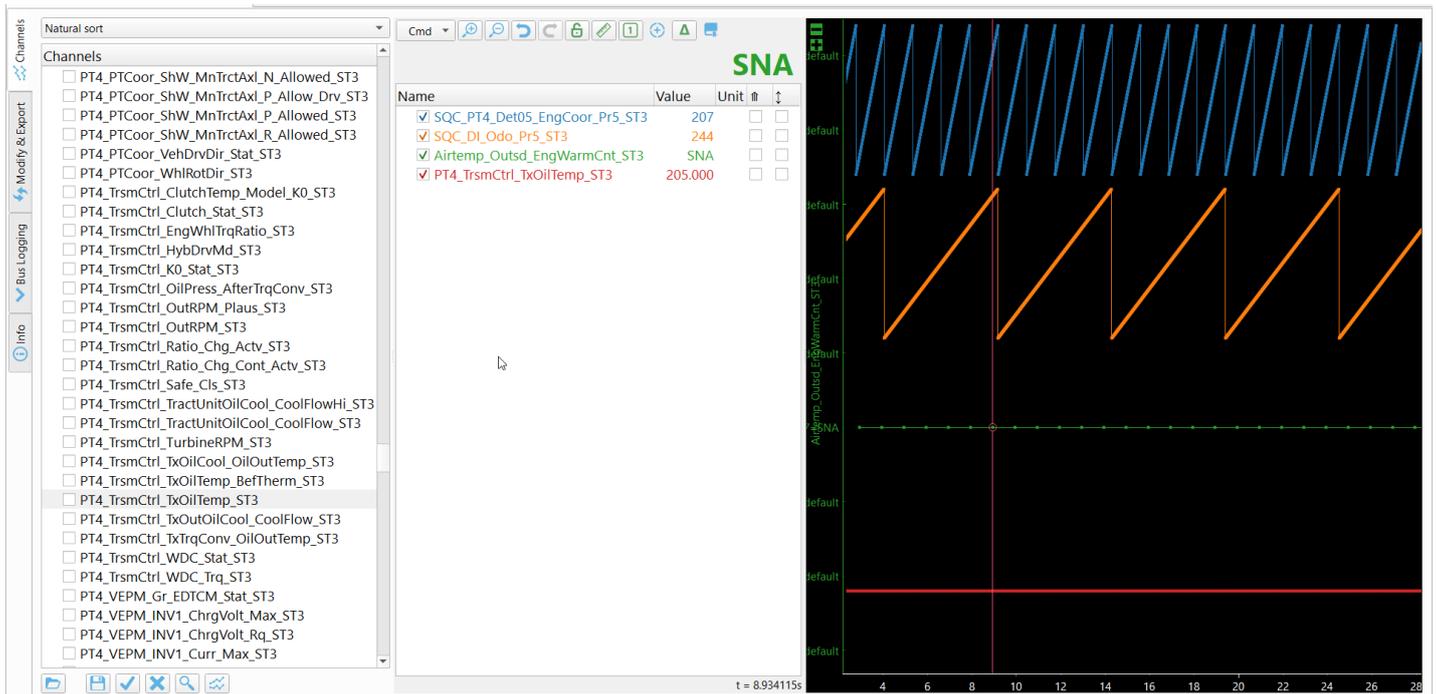
## Sequential Trace

The screenshot shows the HoPHIL UI interface. At the top, there is a 'MESSAGE MONITORING' window with a table of messages. A blue arrow points from the 'Trace' button in this window to the sequential trace view below. The sequential trace view displays a list of messages with columns for Time, Service, PDU Name, ID, Type, Dir, Payload, Interval, Min Inter., and Max Inte.

#	Time	Service	PDU Name	ID	Type	Dir	Payload	Interval	Min Inter.	Max Inte.
1	36893.598836	UDS_SCC	CAN_SCC_TP_RX_Cb0_Phys_Tp	8v7C0	CAN_MESSAGE	TX	03 39 02 2F CC CC CC CC	52893...	-39726...	322377...
2	36893.593697	UDS_SCC	CAN_SCC_TP_TX_Cb0_Tp	8v7A0	CAN_MESSAGE	RX	00 13 59 02 FF 44 00 50 28 44 00 60 2C 44 00 80 2C 44 00 80 2C 44 00 81 2C 13 0E 80	1528...	-39726...	322377...
3	36895.118864	UDS_SCC	CAN_SCC_TP_RX_Cb0_Phys_Tp	8v7C0	CAN_MESSAGE	TX	04 14 FF FF FF CC CC CC	1528.03	-39726...	322377...
4	36895.123699	UDS_SCC	CAN_SCC_TP_TX_Cb0_Tp	8v7A0	CAN_MESSAGE	RX	03 7F 14 13 00 00 00 00	1530	-39726...	322377...
5	36896.346825	UDS_SCC	CAN_SCC_TP_RX_Cb0_Phys_Tp	8v7C0	CAN_MESSAGE	TX	02 10 03 CC CC CC CC CC	1225.96	-39726...	322377...
6	36896.353795	UDS_SCC	CAN_SCC_TP_TX_Cb0_Tp	8v7A0	CAN_MESSAGE	RX	06 50 03 00 33 0E 14 00	1226.01	-39726...	322377...
7	36899.348885	UDS_SCC	CAN_SCC_TP_RX_Cb0_Phys_Tp	8v7C0	CAN_MESSAGE	TX	02 11 01 CC CC CC CC CC	23064...	-39726...	322377...
8	36899.394606	UDS_SCC	CAN_SCC_TP_TX_Cb0_Tp	8v7A0	CAN_MESSAGE	RX	03 7F 11 78 00 00 00 00	18	-39726...	322377...
9	36899.484608	UDS_SCC	CAN_SCC_TP_RX_Cb0_Phys_Tp	8v7C0	CAN_MESSAGE	RX	03 7F 11 78 00 00 00 00	18	-39726...	322377...
10	36899.639697	UDS_SCC	CAN_SCC_TP_TX_Cb0_Tp	8v7A0	CAN_MESSAGE	RX	02 51 01 00 00 00 00 00	235	-39726...	322377...

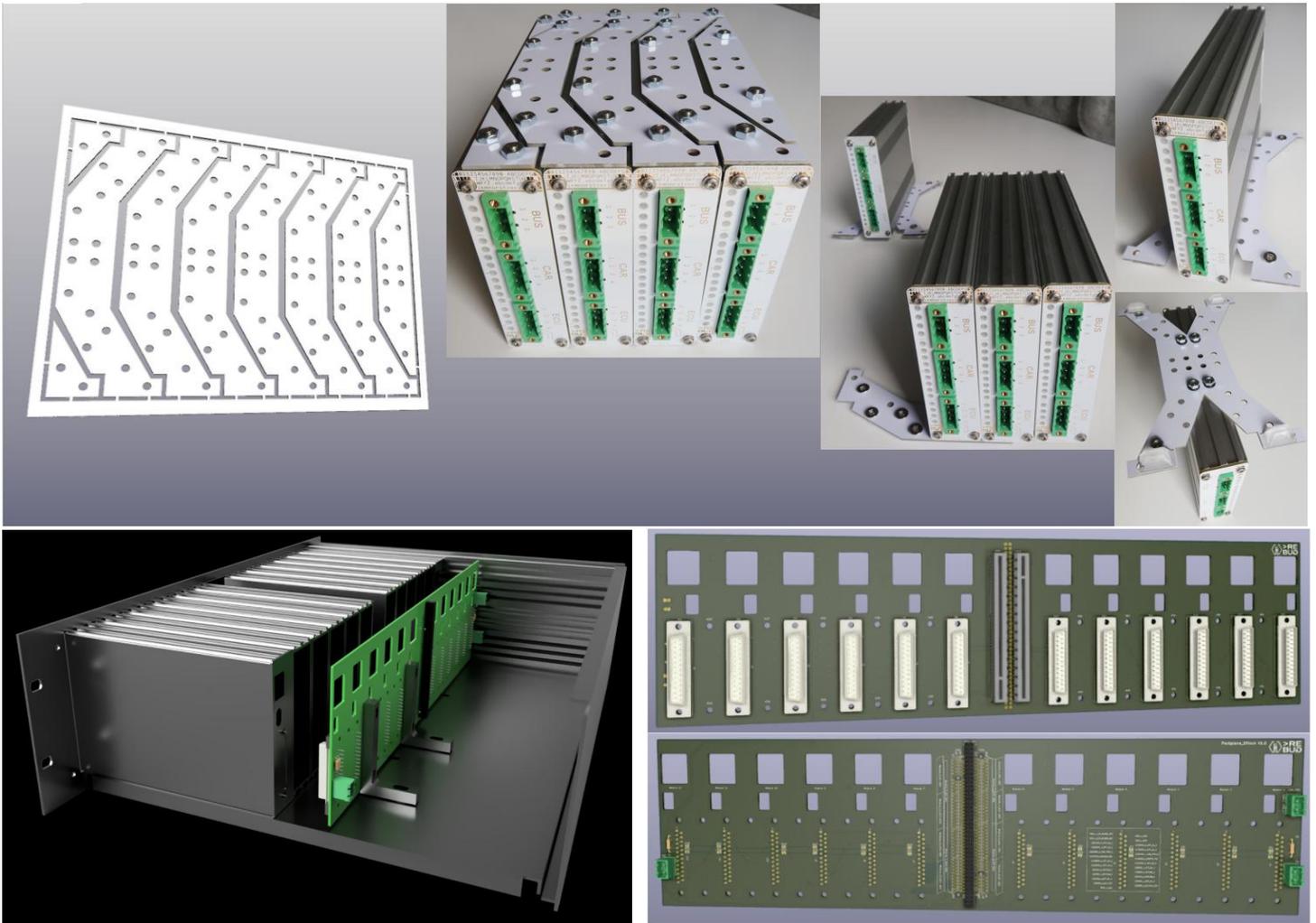
Element	Description	Details
Trace	Display a subset of messages in a sequential trace view.	<p>Typically used for analyzing protocols such as UDS, where each message may depend on the previous one.</p> <p>Select a message in the trace and activate the trace view to display it.</p>

## Offline Recording Signal Viewer (ASAM MDF)



Element	Description	Details
Offline Recording View	ASAMMDF is a powerful open source MDF viewer for MF4 recording files typically used in automotive industry.	<p>HoPhiL records data in the .mf4 format and supports the use of ASAMMDF which is a powerful open-source offline viewer with advanced features comparable to commercial tools.</p> <p>Just a few of the most used features are mentioned:</p> <ul style="list-style-type: none"> <li>- Physical/Raw/Hex/binary signal representation</li> <li>- Cursor, Differential Cursors</li> <li>- Step Modes, Stacking of signals</li> <li>- Computed Signals</li> <li>- Predefined Signal-Sets</li> <li>- Statistics</li> </ul>

## Mounting Concepts



## Mounting Varieties

Element	Details	Notes
Scalable Mounting System	Simple but most applicable concept. Highest flexibility in mounting single or multiple HoPHiL real time nodes. The V-Groove Concept allows fast mounting / dismantling.	
V-Groove Concept	Just use our countersunk head screws to fix the hardware on your already existing mounting racks.	
19-inch Rack	Up to 12 devices and a signal routing interface in the middle of the 3U rack will fit to existing 19-inch systems.	Our backplane connects up to 12 devices and a center slot serves as signal interface. Devices are hot-swappable.
DIN Rail	28mm aluminum clip to mount on a DIN Rail.	

CAN_PRIV_L	1	1
OPT_A1_1	3	3
OPT_A2_1	5	5
OPT_A3_1	7	7
OPT_A4_1	9	9
OPT_B1_1	11	11
IO_EXP_1	13	13
IO_EXP_3	15	15
IO_EXP_5	17	17
OPTION_1	19	19
OPTION_3	21	21
OPT_B1_3	23	23
OPT_B1_5	25	25
D32_IO	27	27
D4_IO_PWM	29	29
D34_IO_RX8	31	31
OPT_B1_GPIO_SCB_EXT_3	33	33
GND	35	35
RS232_TX1	37	37
RS232_RX1	39	39
GND	41	41
GND	43	43
D27_IO_A13_SCK1	45	45
D26_IO_A12_MOS11	47	47
GND	49	49
GND	51	51
GND	53	53
GND	55	55
GND	57	57

CAN_PRIV_H	2	2
OPT_A1_2	4	4
OPT_A2_2	6	6
OPT_A3_2	8	8
OPT_A4_2	10	10
OPT_B1_2	12	12
IO_EXP_2	14	14
IO_EXP_4	16	16
IO_EXP_6	18	18
OPTION_2	20	20
OPTION_4	22	22
OPT_B1_4	24	24
OPT_B1_GPIO_SCB_EXT_2	26	26
OPT_B1_GPIO_SCB_EXT_1	28	28
GND	30	30
GND	32	32
GND	34	34
GND	36	36
D6_IO_PWM	38	38
D5_IO_PWM	40	40
D3_IO_PWM	42	42
D2_IO_PWM	44	44
D1_IO_TX1_MISO1_CTX2_PWM	46	46
D0_IO_RX1_CS1_CRX2_PWM	48	48
GND	50	50
GND	52	52
GND	54	54
GND	56	56
GND	58	58

5V	67	67
5V	69	69
3V3	71	71
12V_BOARD_NET	73	73
12V_BOARD_NET	75	75

5V	68	68
5V	70	70
12V_BOARD_NET	72	72
12V_BOARD_NET	74	74

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5V_VHST	1	1
D48_IO_CS0_RX8	3	3
D35_IO_TX8	5	5
D54_IO_D3_MISO2	9	9
GND	11	11
GND	13	13
+12V	15	15
+12V	17	17
D18_IO_A4_SDA0_QUADTIM	19	19
D49_IO_D1_SCK2	21	21
D15_IO_A1_RX3_QUADTIM	23	23
D19_IO_A5_SCL0_QUADTIM	25	25
D21_IO_A7_RX5	27	27
D39_IO_A15_MISO1	29	29
D28_IO_RX7_PWM	31	31
D52_IO_D0_RX1	33	33
GND	35	35
D13_IO_LED_SCK0_QUADTIM	37	37
D12_IO_MISO0_QUADTIM	39	39
D9_IO_PWM	41	41
GND	43	43
D+	45	45
D-	47	47
GND	49	49
GND	51	51
GND	53	53
GND	55	55
GND	57	57

D37_IO_CS0_PWM	2	2
D36_IO_CS0_PWM	4	4
D53_IO_CLK_TX1_PWM	6	6
D40_IO_A16	8	8
D51_IO_CS1_SCL1_PWM	10	10
D23_IO_A9_CRX1_PWM	12	12
+12V	14	14
+12V	16	16
+12V	18	18
D29_IO_TX7_PWM	20	20
D25_IO_A11_RX6_SDA2_PWM	22	22
D41_IO_A17	24	24
D24_IO_A10_TX6_SCL2_PWM	26	26
D14_IO_A0_TX3_QUADTIM	28	28
D20_IO_A6_TX5	30	30
D22_IO_A8_CTX1_PWM	32	32
D38_IO_A14_CS1	34	34
D33_IO_PWM	36	36
D50_IO_D2_MOSI2	38	38
GND	40	40
D11_IO_MOSI0_QUADTIM	42	42
D10_IO_CS0_QUADTIM	44	44
RESET	46	46
D17_IO_A3_TX4_SDA1	48	48
D16_IO_A2_RX4_SCL1	50	50
GND	52	52
GND	54	54
GND	56	56
GND	58	58

5V	67	67
5V	69	69
3V3	71	71
12V_BOARD_NET	73	73
12V_BOARD_NET	75	75

5V	68	68
5V	70	70
12V_BOARD_NET	72	72
12V_BOARD_NET	74	74

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M2

